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MEMORANDUM

CONCERNING THE DRAINAGE AND SEWERAGE CONDITIONS IN CHICAGO

AND THE

DIVERSION OF 10,000 C. F. S. FROM LAKE MICHIGAN AT CHICAGO

ISSUED BY

THE BOARD OF TRUSTEES

OF

THE SANITARY DISTRICT OF CHICAGO

CHICAGO, ILLINOIS

DECEMBER, 1923

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515-76

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PRELIMINARY STATEMENT

The Sanitary District of Chicago is seeking special Congressional sanction for its diversion of 10,000 cubic feet per second of water from Lake Michigan at Chicago.

To acquaint the public in general with the facts relative to this matter the Sanitary District is presenting this memorandum, which is intended to describe concisely the drainage and Sanitary conditions in Chicago and vicinity, and to demonstrate the need of the diversion mentioned. In connection with this memorandum and as a part of the same is an Appendix "A" in which are outlined the historical facts preceding the organization of the Sanitary District, including those related and incident to its growth and development, also the facts leading up to and surrounding the creation of the works for the Chicago diversion; the facts with reference to the issuance of the original permit for the opening of the Main Channel of the Sanitary District and the limitation upon such permit made by the Secretary of War, in 1903, the facts leading up to and surrounding the making of the Treaty between the United States and Great Britain concerning Canadian boundary waters 1909-10; and the effect of the Treaty, foreclosing Canadian interests from objecting to any diversion of 10,000 cubic feet per second at Chicago.

NEED OF SEWAGE DISPOSAL

Since 1840, when Chicago had a population of only 4,470, Lake Michigan has been the source of the municipal water supply.

The first sewers built in Chicago were constructed in 1856 to drain into Lake Michigan either directly or by way of the Chicago River. From that time until the organization of the Sanitary District and thereupon the construction of its diversion works, the same general policy was followed in sewer construction.

The rapid growth in population of the City of Chicago, accompanied by the necessary expansion of the waterworks and sewer systems, led to a state of pollution of Chicago's water supply that by 1885 menaced the health of every inhabitant. The annual Typhoid Fever death rate was appallingly high and epidemics of such fever were frequent. The Chicago River had become a public nuisance of not only national but even world wide fame. At that time, Chicago was a city of 681,000 people and the condition of affairs was so serious as to require an immediate solution of the problem in a comprehensive way.

The Illinois and Michigan Canal, completed in 1848, and constructed pursuant to express congressional sanction by act of Congress passed in 1827, and pursuant to the act of 1836 of the General Assembly of Illinois, was used until the opening of the Drainage Canal to furnish a partial outlet for the sewage of Chicago. This Canal, however, by reason of the smallness of its capacity, was but a makeshift.

ORGANIZATION OF THE SANITARY DISTRICT

The Sanitary Project was developed by the City of Chicago with the co-operation of the State Board of Health of Illinois and a joint committee of the Illinois General Assembly in the years 1885-1889. To study and report upon the problem Chicago created the Drainage and Water Supply Commission consisting of eminent Civil Engineers. Three methods of the solution of the problem of disposal

of the sewage of the Chicago District were considered by this Commission: First, the discharge of sewage into Lake Michigan at one end of the city and the taking of water supply from the Lake at the other extreme end of the city; Second, the disposal of sewage on land by intermittent filtration over a vast sewage farm (as large as 15,000 acres); Third, the discharge of sewage into the Des Plaines River by means of ship canal, and the resultant disposal by dilution. The third method, recommended by the Commission, was chosen as the basis of the Sanitary District Act.

Thereupon the Sanitary District of Chicago was created by act of the Illinois State Legislature May 29, 1889, and the validity of the act was affirmed by the State Supreme Court on June 12, 1890. Its purpose was to provide a Main Channel or outlet and necessary adjuncts to divert the sewage of Chicago and adjacent towns from Lake Michigan, thus protecting the municipal water supply from contamination by sewage. To dispose of sewage by dilution and provide an outlet into the Illinois River, the act required that such channel should be made of such size and capacity as to provide a minimum dilution of 3.33 cubic feet per second for every 1,000 people.

Subsequent amendments to the Sanitary District Act, authorized the utilization of the water power incidentally created (1903); and require the construction of sewage treatment works to supplement dilution of sewage (1921). Construction work performed in compliance with these amendments will be discussed in proper order in later sections of this memorandum.

THE DILUTION PROJECT

In the design and construction of the Main Drainage Canal, the first work of the Sanitary District, consideration was given to the provisions of Section 23 of the Act which

required that the channel should have a "size and capacity to maintain a continuous flow throughout the same of not less than 600,000 cubic feet of water per minute with a current of not more than three miles per hour." In subsequent design, this same flow of 10,000 cubic feet per second has been used.

For the disposal of sewage by dilution, the Sanitary District has constructed the following channels:

Main Drainage Canal, twenty-eight miles long from the Chicago River at Robey Street to the Controlling Works at Lockport, depth 24 feet, minimum width 160 feet; work started 1892, water turned in January 2, 1900. Work involved diverting Des Plaines River over a stretch of 13 miles. Flow capacity of Main Channel approximately 10,000 cubic feet per second. Cost of project $27,357,668.27.

Des Plaines River Improvement, the widening and deepening of the Des Plaines River from the Lockport Controlling Works south for six miles through Joliet; work started 1898, completed September, 1901. Channel designed to carry flow of 25,000 cubic feet per second, the combined flood flow of both the Main Channel and Des Plaines River. Cost of project $2,333,571.72.

Main Channel Extension, four miles long, constructed between 1903 and 1907, from the Lockport Controlling Works to the Upper Basin in Joliet, to concentrate at one point 34 feet of fall in the water of the Main Channel and utilize the potential power running to waste. Dimensions and capacity same as Main Channel. Cost of project $3,167,003.05.

Chicago River Improvement, five miles of the South Branch from Lake Street to Robey Street, widened to 200 feet minimum and deepened to 26 feet, work carried on from 1897 to 1920; more than two miles of the North Branch from Belmont Avenue to Lawrence Avenue straight-

ened, widened and deepened between 1904 and 1907. Cost of project $12,903,619.48. The Main Branch of the Chicago River and the North Branch below Belmont Avenue have been improved by the Federal Government.

North Shore Channel, eight miles long, from Lake Michigan at Wilmette to the North Branch of the Chicago River at Lawrence Avenue, depth 13 feet, width 80 feet, constructed between 1907 and 1910; flow capacity 1,000 cubic feet per second. Cost of project $4,106,489.84.

Calumet-Sag Channel, sixteen miles long from the Little Calumet River near Blue Island to a junction with the Main Channel at Sag, depth 20 feet, minimum width 60 feet; work begun 1911, completed 1922. Flow capacity 2,000 cubic feet per second when flow in upper Main Channel is 8,000 c. f. s. with total flow in Main Channel below Sag 10,000 cubic feet per second. Cost of project $14,035,529.28.

SEWAGE PUMPING STATIONS

In addition to canal construction and river improvement, building of new sewers to replace old sewers draining into Lake Michigan was necessary. Between 1898 and 1905 the City of Chicago constructed intercepting sewers along the lake front, the sewer on the South Side leading to the Thirty-ninth Street Pumping Station and the sewer on the North Side leading to the Lawrence Avenue Pumping Station, both stations constructed by the City but turned over to the Sanitary District to operate. Flushing pumps are located at both these sewage pumping stations, the one at Lawrence Avenue installed by the City to aid in flushing the North Branch of the River, and the two at Thirty-ninth Street installed by the Sanitary District to flush out the South Fork of the South Branch, or the Stockyards

slip. The construction cost of these projects to the Sanitary District has been:

Thirty-ninth Street Pumping Station	$754,885.51
Lawrence Avenue Pumping Station	49,755.42
	$804,640.93

The expenditures of the City of Chicago on the construction of intercepting sewers along the lake front and on the sewage pumping stations mentioned above have been $6,706,804.37.

AUXILIARY SEWERS

Certain sewers have been constructed as auxiliaries of the Main Channel to improve the circulation in certain parts of the Chicago River. Among these are the Stock Yards sewer and the West Thirty-ninth Street conduit, built at a cost of $240,108.84, to carry the sewage of Packingtown direct to the Main Channel instead of discharging into the Stock Yards Slip. The Thirty-ninth Street Conduit Extension, now under construction, $593,357.03 having been expended on it, with an estimate of approximately $1,983,000.00 more to complete, will permit the filling in of the Stock Yards Slip thereby eliminating a practically stagnant arm of the South Fork of the South Branch of the River. This sewer will also serve as a part of the collecting sewer system of the South-west Side Sewage Treatment Project.

MISCELLANEOUS CONSTRUCTION

Other miscellaneous construction work, such as small sewers, work on the LaGrange and Kampsville Dams in the Illinois River, work on the Des Plaines at Hickory Creek, certain improvements at the old Bridgeport Pumping Plant of the I. & M. Canal, etc., has cost the Sanitary District $812,254.66.

NORTH SHORE SEWERS

The above mentioned projects completed the drainage and sewage diversion from Lake Michigan within the Chicago City Limits. The sewage of the North Shore Towns was diverted from Lake Michigan by the North Shore Sewer, constructed 1913 to 1916, extending from Glencoe down to the North Shore Channel at Wilmette; and by the Evanston sewer and pumping station, constructed 1916 to 1921, extending along the Lake Front in Evanston and leading back to the North Shore Channel. These sewers and the pumping station, though classed here as a part of the Dilution Project, are equally a part of the North Side Sewage Treatment Project, mentioned later. They are now serving to drain sewage into the North Shore Channel. Upon the completion of the North Side Sewage Treatment Plant in 1928 they will drain into the Plant. The cost of these projects has been:

North Shore Sewer	$ 690,376.62
Evanston Sewer	1,251,786.06
Evanston Pumping Station	511,833.87
	$2,453,996.55

In the design of intercepting sewers and channels in the Dilution Project, the idea has been kept in mind that ultimately sewage treatment would be required over practically the entire District to supplement disposal by dilution. Accordingly many of the sewers which have been designed as tributaries of the canals in the dilution scheme will be used as collecting sewers in the Treatment Projects. The Calumet, Evanston and North Shore Sewers are examples of sewers which will have a double use. In this memorandum all structures are classified according to their present use. Even the canals will serve their part in the Treatment Projects as effluent channels diverting the effluent from the plants away from Lake Michigan at all times.

SUMMARY OF CONSTRUCTION COSTS

This concludes the construction program of the Sanitary District as regards the disposal of sewage by dilution. Its cost may be summarized as:

Main Drainage Canal	$27,357,668.27
Des Plaines River Improvement	2,333,571.72
Main Channel Extension	3,167,003.05
Chicago River Improvement	12,903,619.48
North Shore Channel	4,106,489.84
Calumet-Sag Channel	14,035,529.28
Sewage Pumping Stations	804,640.93
Auxiliary Sewers	833,465.87
Miscellaneous Construction	812,254.66
North Shore Sewers	2,453,996.55
Bare Construction Cost	$68,808,239.65
Administration, legal expense, clerical expense, damages, etc	5,765,404.33
Interest on bonds for construction	16,313,221.63
Expenditures by City of Chicago	6,706,804.37
Total	$97,593,669.98

In addition to the $97,593,669.98 expended for CONSTRUCTION the Sanitary District has expended some $11,434,857.95 on maintenance, administration and operation bringing the total expenditures on account of the Dilution Project to well over one hundred millions of dollars.

As a result of this expenditure, there is available a system of canals and sewers which will for 365 days out of every year keep the sewage of the Chicago District out of Lake Michigan, the source of the municipal water supply. This system, if worked up to its designed capacity of 10,000 cubic feet per second of flow, will, at the rate of dilution required by the State law, dispose of the sewage of 3,000,000 people.

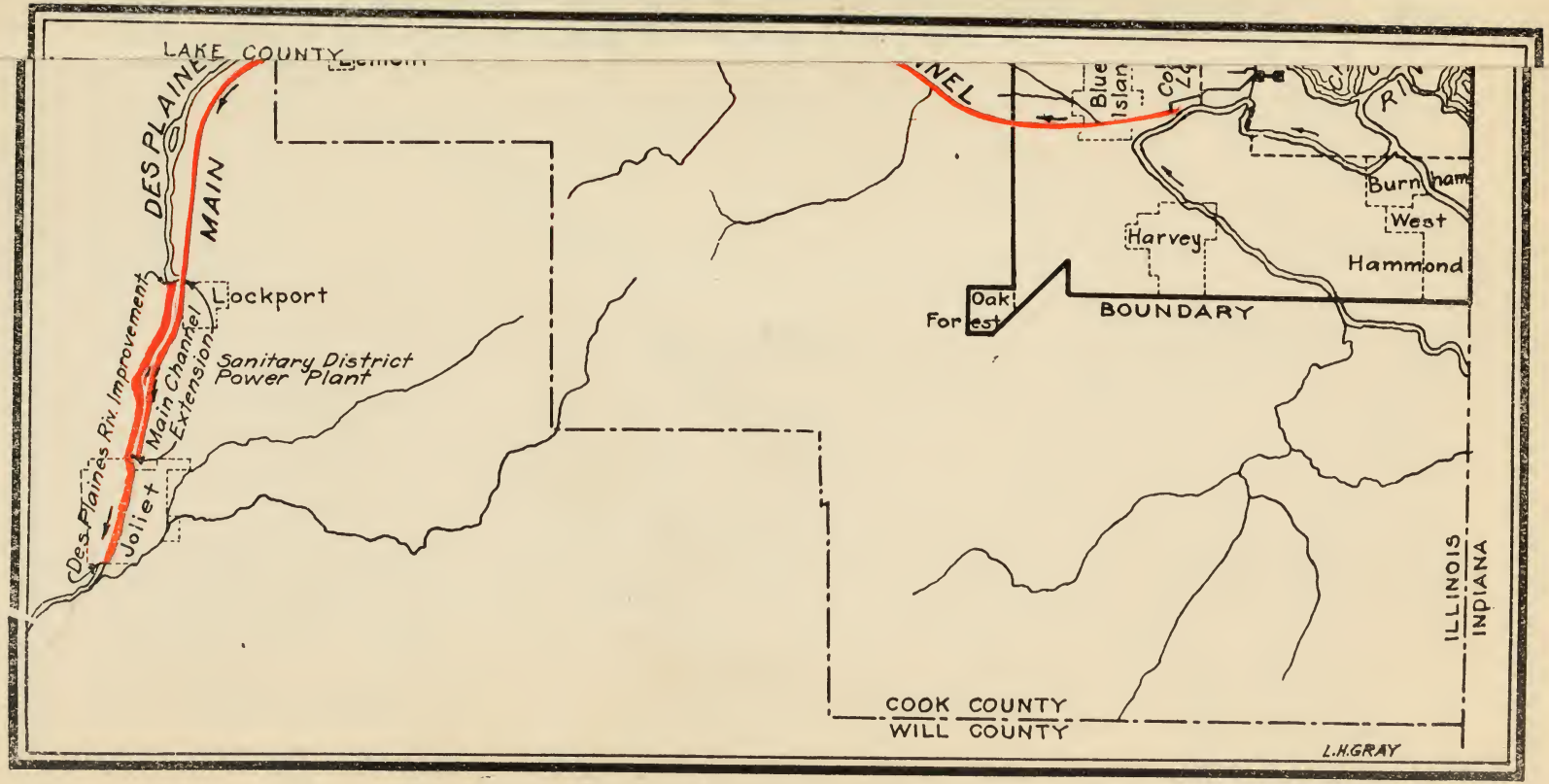

LAKE COUNTY
DES PLAINES MAIN
Lockport
Des Plaines Riv. Improvement
Joliet Main Channel Extension
Sanitary District Power Plant
Blue Island
Harvey
Burnham
West Hammond
Oak Forest
BOUNDARY
ILLINOIS
INDIANA
COOK COUNTY
WILL COUNTY
L.H.GRAY

Exhibit "A"

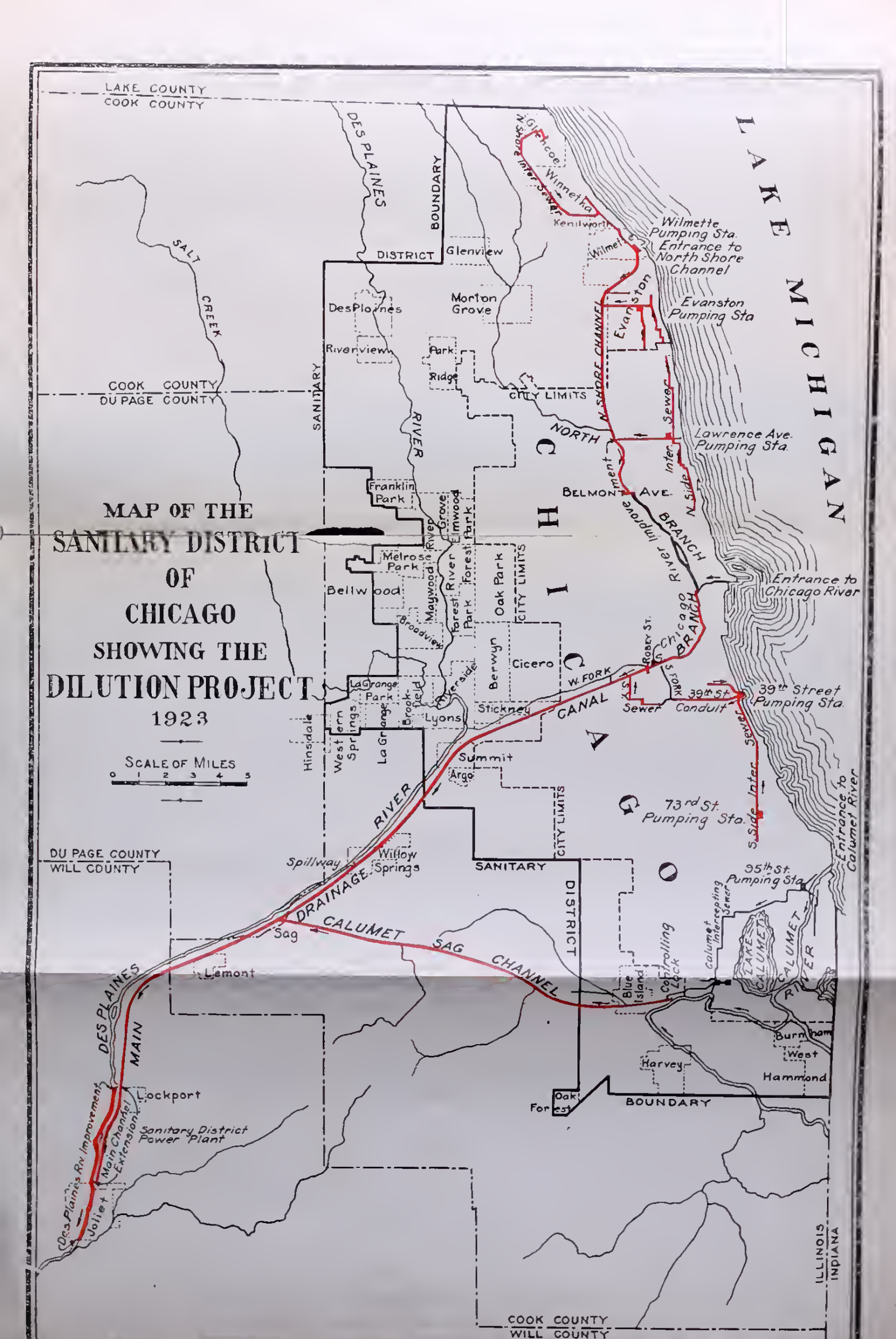

MAP OF THE
SANITARY DISTRICT
OF
CHICAGO
SHOWING THE
DILUTION PROJECT
1923
SCALE OF MILES
0 1 2 3 4 5
LAKE COUNTY
COOK COUNTY
COOK COUNTY
DU PAGE COUNTY
DU PAGE COUNTY
WILL COUNTY
COOK COUNTY
WILL COUNTY
ILLINOIS
INDIANA
LAKE MICHIGAN
CHICAGO
DES PLAINES
SALT CREEK
RIVER
SANITARY DISTRICT BOUNDARY
CITY LIMITS
N. Shore Inter. Sewer
Winnetka
Kenilworth
Wilmette
Wilmette Pumping Sta.
Entrance to North Shore Channel
N. SHORE CHANNEL
Evanston
Evanston Pumping Sta
Glenview
Morton Grove
Des Plaines
Riverview
Park Ridge
Lawrence Ave. Pumping Sta.
N. Side Inter. Sewer
NORTH BRANCH
Chicago River Improvement
BELMONT AVE.
Entrance to Chicago River
Franklin Park
Melrose Park
Bellwood
Maywood
River Grove
Elmwood Park
Forest Park
River Forest
Oak Park
Broadview
Berwyn
Cicero
Riverside
Brookfield
LaGrange Park
LaGrange
Western Springs
Hinsdale
Lyons
Stickney
Summit
Argo
W. FORK
CANAL
S. FORK
ROBEY ST.
Chicago BRANCH
39th St. Sewer
39th St. Conduit
39th Street Pumping Sta.
S. Side Inter. Sewer
73rd St. Pumping Sta.
Entrance to Calumet River
95th St. Pumping Sta.
Calumet Intercepting Sewer
CALUMET RIVER
LAKE CALUMET
Spillway
Willow Springs
DRAINAGE
RIVER
SANITARY DISTRICT
CALUMET SAG CHANNEL
Sag
Lemont
Controlling Lock
Blue Island
Harvey
Burnham
West Hammond
Oak Forest
BOUNDARY
DES PLAINES
MAIN
Lockport
Des Plaines Riv. Improvement
Main Channel Extension
Joliet
Sanitary District Power Plant
L.H.GRAY

Exhibit "A"

Exhibit A is a map showing in red the various works constructed for the Dilution Project.

The diversion works as now constructed provide for a complete diversion from Lake Michigan of all the sewage and drainage, and of 10,000 cubic feet per second of water in the following manner: 6,250 c. f. s. direct from Lake Michigan through the Chicago River to the junction of the south and north branches. At this point the diversion is augmented by 1,750 c. f. s. coming in from the North Branch from two diversion sources—Lawrence Avenue Pumping Station at Lawrence Avenue, 750 c. f. s. and the North Shore Channel terminating at the lake shore in Wilmette, 1,000 c. f. s. The 8,000 c. f. s. diversion then proceeds along the South Branch to the South Fork where it is augmented by 2,000 c. f. s. diversion at the 39th Street Pumping Station, making a total of 10,000 cubic feet per second. The Calumet-Sag Channel has a capacity of 2,000 cubic feet per second and enters the Main Channel at Sag, Illinois, a number of miles south and west of the northern terminus of the Main Channel. It is designed to divert the sewage of the southern section and to decrease the load on the other diversions and thus decrease the current in the Chicago River, but it is not designed to increase the total diversions over the 10,000 cubic feet per second.

ADDITIONAL EXPENDITURES FOR NAVIGATION.

The Main Drainage Canal was constructed as a Sanitary and Ship Canal and the Chicago River was improved in such a way as to make it navigable to ships plying the Great Lakes. Navigation features added considerably to the cost of the Calumet-Sag Channel. A study of the construction costs of the Dilution Project indicates that if the channels had all been constructed of their present flow capacities, with the same ultimate flow capacity of 10,000 c. f. s. for the main outlet, with navigation features omitted, there could have been effected a saving of $8,500,000.00.

This is the amount which the Sanitary District has contributed to the cost of a navigable waterway which will some day be completed from the Great Lakes to the Gulf of Mexico.

If in the beginning the amount of diversion from Lake Michigan had been determined and fixed at 4,167 c. f. s. and the Sanitary District had constructed the various branches of the Dilution Project as they were built but of a total ultimate capacity of 4,167 c. f. s. instead of 10,000 c. f. s., with no navigation features, there could have been effected a saving of $25,300,000.00. This is the amount the Sanitary District has expended for the benefit of navigation and a greater diversion than 4,167 c. f. s.

If in the beginning the amount of diversion from Lake Michigan had been determined and fixed at 4,167 c. f. s. and the Sanitary District had constructed a Dilution Project with an outlet capacity of only 4,167 c. f. s., omitting the auxiliary channels and all navigation features, there could have been effected a saving of approximately $37,000,000.00.

If the diversion from Lake Michigan should be fixed at 4,167 c. f. s. and a flow of this amount should not be exceeded in the Drainage Canal, it would require only a few years for silting to take place in the Main Drainage Canal, Calumet-Sag Channel and the Chicago River to such an extent that the whole system would have a capacity of only 4,167 c. f. s. instead of 10,000 c. f. s. as at present. Under such a condition, when the necessity would arise to flow more than 4,167 c. f. s. to dispose of flood waters, it would be impossible to flow a sufficient amount because of lack of capacity. The deposits in the channel would be formed from sludge, and years of experience on the Drainage Canal indicate that compacted sludge will not scour.

It is pertinent to state that the diversion from Lake Michigan at Chicago benefits navigation in the Mississippi

TYPHOID FEVER DEATH RATE PER 100,000 POPULATION

City	Population 1920	Average Yearly Rate for Periods						
		1890-1894	1895-1899	1900-1904	1905-1909	1910-1914	1915-1919	1920-1922
Baltimore	733,826	44.0	36.6	36.8	34.4	27.6	14.4	4.7
Boston	748,060	32.4	32.0	23.0	18.2	9.1	3.4	2.0
Cleveland	796,841	50.6	32.6	56.8	15.2	12.1	5 6	2.9
Detroit	993,678	43.4	19.2	22.0	21.6	18.2	10.3	5.4
Milwaukee	457,147	32.0	17.6	17.4	23.0	22.0	7.5	2.2
New York	5,620,048	21.6	17.4	17.0	14.4	9.3	4.1	2.3
Philadelphia	1,823,779	50.2	45.8	49.2	48.4	13.9	5.9	2.8
St. Louis	772,897	48.4	20.4	39.0	18.0	14.2	7.9	3.5
Washington	437,571	86.2	64.8	63.2	41.6	18.4	10.1	6.1
Average of 9 Cities		45.4	31.8	36.0	26.1	16.1	7.7	3.5
Chicago	2,701,705	92.2	36.6	29.2	16.6	10.1	2.9	1.1

Exhibit "B"

Valley. A flow of 10,000 c. f. s. through the Drainage Canal will not only raise the low water stage of the Illinois River but will raise the low water stage of the Mississippi River between St. Louis and Cairo approximately one and one-half feet. To increase and maintain the low water depth of the Mississippi River at this place by any other means would cost the Federal Government many millions of dollars.

OPERATION OF DILUTION PROJECT

The results of the operation of the Dilution Project have been all that could be expected. Water borne diseases have been practically eliminated in Chicago. The death rate from Typhoid Fever is the best measure of these results. The rate in Chicago has declined from a maximum of 172.0 per 100,000 population in 1891 to 1.0 per 100,000 population in 1922. Credit for the total decrease in Typhoid Fever death rate should not be given entirely to the operation of the Dilution Project or the Drainage Canal. Up to date sanitary science has lessened the rate in all cities. By the amount the Chicago rate has decreased more than the rate of other large cities, can the effect of the Dilution Project be measured. Exhibit B is a tabulation of statistics of the Typhoid Fever death rates in Chicago and nine other large cities, three of which are adjacent to the Great Lakes. These figures indicate that the average yearly death rate per 100,000 population for the ten year period 1890 to 1899 inclusive (the ten years immediately preceding the opening of the Drainage Canal) was 64.4 for Chicago and 38.5 for the group of nine (9) cities, Baltimore, Boston, Cleveland, Detroit, Milwaukee, New York, Philadelphia, St. Louis and Washington. The average yearly rate for the past three years, 1920 to 1922, inclusive, was 1.1 for Chicago and 3.5 for the group of nine (9) cities. **Chicago's rate** is now **1.7 per cent** of what it was prior to 1900. **The average rate of nine other large cities** is now **9.1 per cent** of what it was prior to 1900.

WATER POWER AT LOCKPORT

In the four mile reach below the Lockport Controlling Works, the water flowing from the Main Channel dropped approximately 34 feet. Much potential power was running to waste during the first few years of operation of the canal. The Sanitary District Act was amended in 1903 further authorizing the development of this power and the furnishing of the energy generated therefrom to municipalities within the District. Between 1904 and 1907, the Main Drainage Canal was extended over this four mile reach, the fall concentrated in one spot and a power house installed for the development of water power. The cost of this power plant was $1,395,712.95. Electric current is generated and transmitted to Chicago where it is used in lighting streets, parks and boulevards in Chicago and its suburbs. Much of the current is used by the Sanitary District itself in the operation of the electrically driven sewage pumping stations and the machinery in the sewage treatment plants.

The theoretical power at Lockport with a 34 ft. head and a flow of the designed capacity of the Main Channel, 10,000 c. f. s., making allowance for water for lockage and to regulate flow, is approximately 36,000 h. p. or 27,000 k. w. With an overall efficiency of 80 percent, the possible output would be 21,600 k. w. The actual output of this plant for the past ten years has been

1913	98,000,000 k. w. h.
1914	107,000,000 k. w. h.
1915	110,000,000 k. w. h.
1916	113,000,000 k. w. h.
1917	119,000,000 k. w. h.
1918	120,000,000 k. w. h.
1919	126,000,000 k. w. h.
1920	121,000,000 k. w. h.
1921	117,000,000 k. w. h.
1922	122,551,800 k. w. h.

The output of the Commonwealth Edison Company, operating within the Chicago City Limits, for the year 1922 was 2,225,443,000 k. w. h. with a peak load of 600,000 k. w.

The water power is merely a by-product and it conserves something that otherwise would be wasted. The power is used in operating the plants of the Sanitary District and for furnishing street lights to municipalities at cost. The small amount of day load originally sold to commercial consumers to balance the load curve is now being dropped as rapidly as possible, the Sanitary District using this current in its own plants. No water has ever been used for power that was not diverted and needed for dilution of sewage according to the fixed statutory ratio of 20,000 cubic feet per minute for each 100,000 of population.

SEWAGE TREATMENT

Experiments

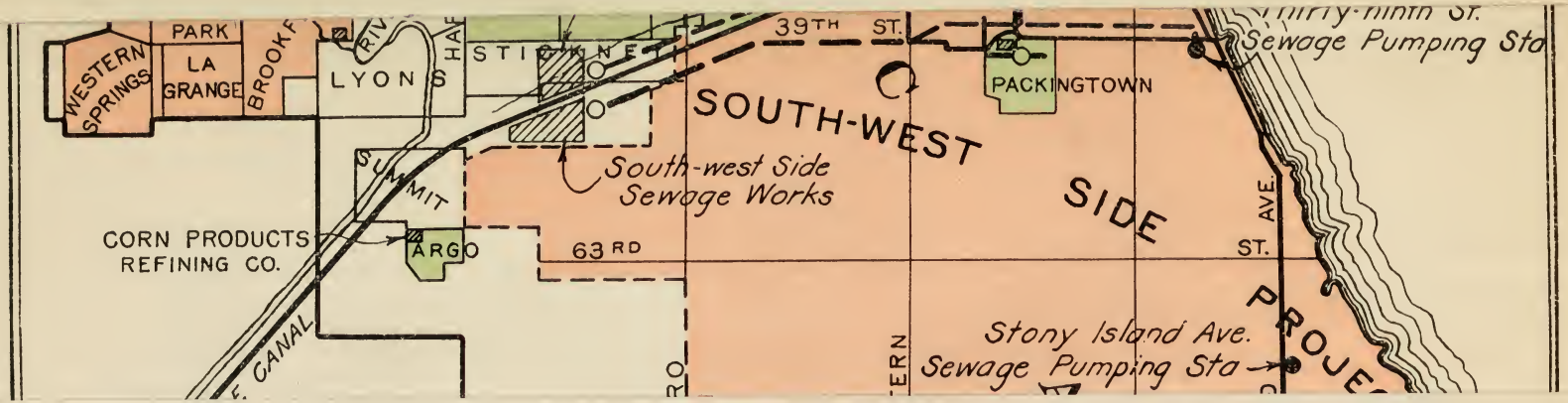
It has long been recognized by the Sanitary District that, in a city growing as is Chicago, a limit would be reached beyond which it would not be feasible to dispose of sewage entirely by dilution. The capacity of all the channels would be taxed and the amount of water that could be withdrawn from Lake Michigan for sewage dilution would be limited. Accordingly as far back as 1908 a thorough study of methods of sewage treatment, other than dilution, was begun. A laboratory was established at Thirty-ninth Street and experts were employed for this study which is still in progress. Experimental Sewage Testing Stations have been built and operated; at Thirty-ninth Street on domestic sewage from 1908 to 1911; at the Stock Yards on its special trade wastes from 1912 to 1914, and on the activated sludge process from 1915 to 1918; along the North Branch on tannery wastes 1919 to 1922; and at Argo on the special wastes of the Corn Products Company from 1920 to date. Nothing has been overlooked which would give the Sanitary District the best and most up to date information on sewage

disposal. The cost of these studies up to January 1, 1923, has been $256,967.43.

The time devoted to the study and investigation of sewage treatment was absolutely necessary to precede the initiation by the Sanitary District of its vast and expensive sewage treatment program. It would have been the part of folly for the Sanitary District to have entered upon a plan for the disposal of sewage by artificial treatment supplementary to the diversion works without having first made a complete and exhaustive study. The art of sewage disposal has been for a great many years in a state of continuing change. Almost as soon as plans for sewage disposal had been adopted, they were discarded as obsolete for some other plan. The Imhoff tanks and sprinkler filter method is not perfect and at times causes nuisances due to odors. In places it has given way to the activated sludge process. The popularity of the activated sludge process is apparently waning due to difficulties in disposing of the sludge and because of cost of operation and other things.

Construction Program

As a result of the studies of sewage treatment, the Board of Trustees of the Sanitary District, by ordinance passed August 7, 1919, adopted a program and project for the construction of artificial sewage treatment plants to be operated supplementary to its sewage, drainage and water diversion works. This program provided for the construction each year of certain plants so that at the end of twenty-five years only half the amount of sewage and wastes then passing through the Drainage Canal would be discharged into the Desplaines River. The Sanitary District has been divided into six divisions and six major treatment projects have been outlined, as shown on the Exhibit C. A seventh division includes miscellaneous small projects for outlying towns and villages. These projects are listed in the order in which their construction


WESTERN SPRINGS
PARK
LA GRANGE
BROOKF
RIV
LYON
HAF
STICKNEY
39TH ST.
PACKINGTOWN
Thirty-ninth St.
Sewage Pumping Sta
SOUTH-WEST SIDE
South-west Side
Sewage Works
SUMMIT
CORN PRODUCTS
REFINING CO.
ARGO
63RD
AVE.
ST.
CANAL
Stony Island Ave.
Sewage Pumping Sta
PROJE

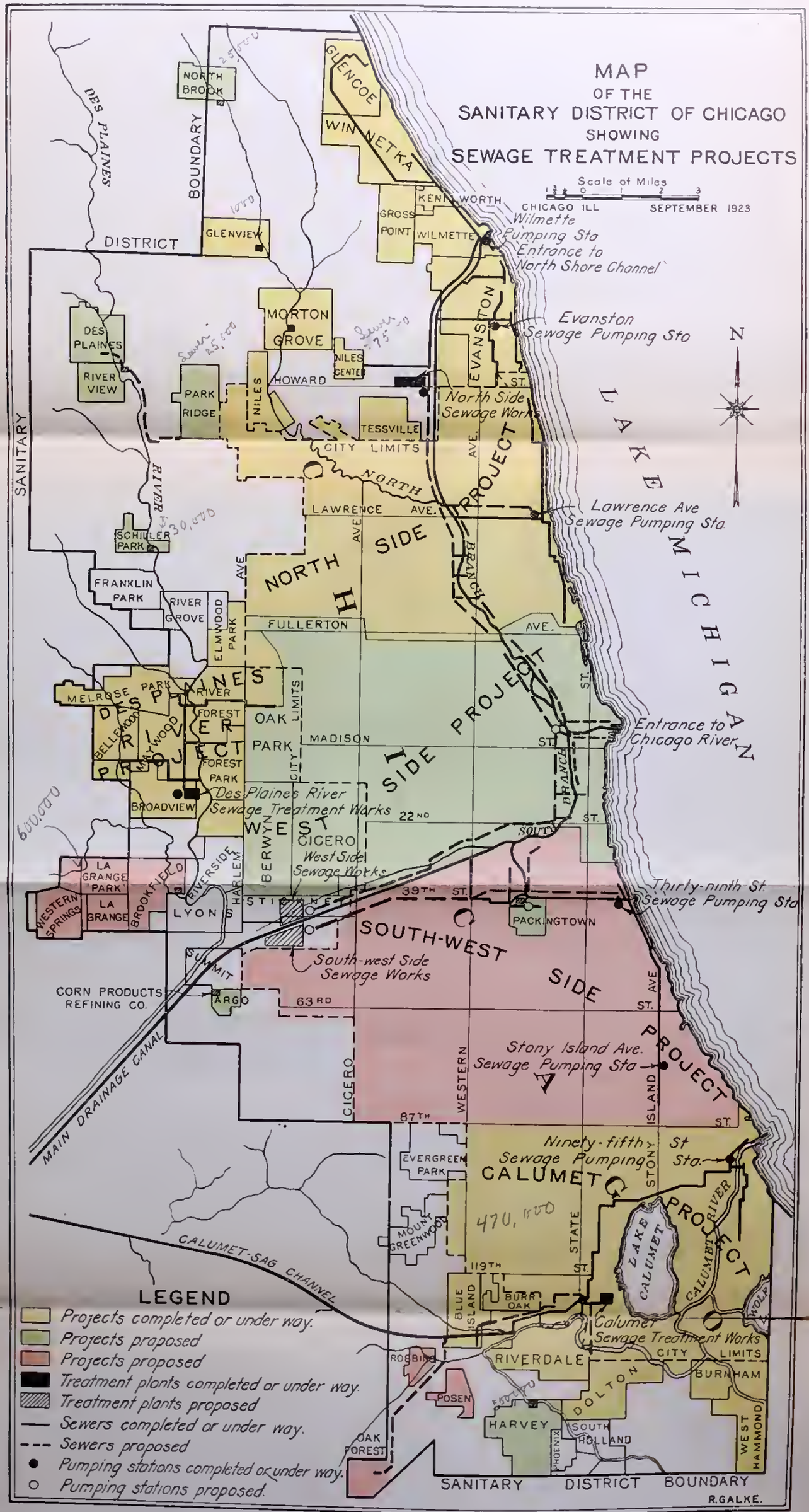

MAP
OF THE
SANITARY DISTRICT OF CHICAGO
SHOWING
SEWAGE TREATMENT PROJECTS
Scale of Miles
CHICAGO ILL
SEPTEMBER 1923
Wilmette Pumping Sta
Entrance to North Shore Channel
Evanston Sewage Pumping Sta
North Side Sewage Works
Lawrence Ave Sewage Pumping Sta
Entrance to Chicago River
Des Plaines River Sewage Treatment Works
West Side Sewage Works
South-west Side Sewage Works
Thirty-ninth St Sewage Pumping Sta
Stony Island Ave. Sewage Pumping Sta
Ninety-fifth St Sewage Pumping Sta
Calumet Sewage Treatment Works
NORTH SIDE PROJECT
WEST SIDE PROJECT
SOUTH-WEST SIDE PROJECT
CALUMET PROJECT
DES PLAINES RIVER PROJECT
SANITARY DISTRICT BOUNDARY
MAIN DRAINAGE CANAL
CALUMET-SAG CHANNEL
LAKE MICHIGAN
CORN PRODUCTS REFINING CO.
LEGEND
Projects completed or under way.
Projects proposed
Projects proposed
Treatment plants completed or under way.
Treatment plants proposed
Sewers completed or under way.
Sewers proposed
Pumping stations completed or under way.
Pumping stations proposed.
R.GALKE.

Exhibit "C"

1919	1920	1921	1922
17,763.44	$8,810.85	$36,014.98	$10,890.23
89,374.03	267,446.85	374,092.00	578,097.09
03,291.79	127,111.66	1,963.07	572.98
.....	1,690.85	201,409.76	591,329.99
1,094.50	260,656.84	2,992,316.07	2,866,606.11
87,714.55	703,526.43	551,004.06	877,825.73
83,450.08	595,292.32	60,042.44	2,333.74
.....	222,220.04	677,345.16	264,893.39
.....	.....	4,649.25	846.82
.....	.....	281,099.77	23,294.78
.....	.....	56,552.46	1,941,747.60
.....	.....	.....	104.76
.....	1,415.00	.....	.....
27,802.78	20,286.84	2,342.54	84.26
			1,942.10
10,491.17	$2,208,457.68	$5,238,831.56	$7,160,551.58

Exhibit "D"

THE SANITARY DISTRICT OF CHICAGO
EXPENDITURES ON SEWAGE TREATMENT PROJECTS TO DECEMBER 31, 1922

PROJECT	Cost	Project Total	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922
Sanitary Improvements, etc.	$ 256,967.43				$25,615.60	$22,752.59	$10,980.24	$14,308.79	$17,167.64	$19,100.94	$13,801.61	$53,471.72	$3,597.75	$2,691.05	$17,763.44	$8,810.85	$36,014.98	$10,890.23
Total		$ 256,967.43																
I. Desplaines River Treatment Project: Treatment Plant	1,441,835.01												26,704.00	6,139.04	189,374.03	267,146.85	374,092.00	578,097.09
Des Plaines River Sewer	663,787.86								107.71	3,366.12	1,029.48		5,894.99	20,450.06	503,291.79	127,111.66	1,963.07	572.98
Oak Park Sewer	794,430.60															1,690.85	201,109.76	591,329.99
Total,		2,900,053.47																
II. Calumet Sewage Treatment Project: Treating Plant and Connecting Conduit	6,124,866.62												4,193.10		1,091.50	260,056.81	2,992,316.07	2,866,606.14
Calumet Sewers	5,049,400.61					1,569.94	2,378.84	2,365.83	404.83	6,930.54	59,361.84	599,829.73	1,085,998.69	970,489.60	187,714.55	703,526.43	551,004.06	877,825.73
Calumet Pumping Station	1,499,402.02								250.00		2,460.36	4,678.94	17,433.73	133,460.41	683,450.08	595,292.32	60,042.41	2,333.71
Calumet Power Plant	1,164,458.59															222,220.04	677,345.16	264,893.39
95th Street Pumping Station	5,496.07																4,649.25	840.82
Total,		13,843,623.91																
III. North Side Sewage Treatment Project: North Side Treatment Plant	304,394.55																281,099.77	23,294.78
North Side Sewers	1,998,300.06																56,552.46	1,941,747.60
Niles Center Sewers	25,362.93										319.27	1,714.53	22,921.09	303.28				104.76
Total,		2,328,057.54																
V. West Side Sewage Treatment Project: 52nd Avenue Sewer	283,379.50		$32.28		10.00	347.93		58,572.85	33,571.99	139,439.86	28,707.52	4,922.35		16,350.72		1,415.00		
Total,		283,379.50																
VII. Miscellaneous Treatment Plants and Sewers: Morton Grove	65,964.31								143.67	9,990.14	2,812.83		1,684.36	816.89	27,802.78	20,286.84	2,342.54	84.26
Small Plants	1,942.10																	1,942.10
Total,		67,906.41																
Total	$19,679,988.26	$19,679,988.26	$32.28		$25,625.60	$24,670.46	$13,359.08	$75,247.47	$51,645.84	$178,827.60	$108,492.91	$664,617.27	$1,168,427.71	$1,150,710.05	$1,610,494.17	$2,208,457.68	$5,238,831.56	$7,160,551.58

Exhibit "D"

	1939	1940	1941	1942 to 1945

THE SANITARY DISTRICT OF CHICAGO
FUTURE CONSTRUCTION SCHEDULE

August 13, 1923.

PROJECT	Estimated Cost	Project Cost	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942 to 1945
I. Desplaines River Treatment Project:																						
Extension Desplaines Treatment Plant	$ 100,000		$ 20,000	$ 80,000																		
Broadview Sewers	200,000				$ 100,000	$ 100,000																
Elmwood Park Sewers	250,000			100,000	150,000																	
Total,		$ 550,000																				
II. Calumet Sewage Treatment Project:																						
Calumet Treatment Plant	370,000		370,000																			
95th Street Pumping Station	1,000,000		400,000	600,000																		
Avenue "N" Sewer	1,276,000		1,276,000																			
Harbor Avenue Sewer	672,000		372,000	300,000																		
Calumet Sewers Contract No. 1	200,000			200,000																		
Extension Blue Island Sewer	425,000							$ 425,000														
Sewer to Riverdale and Dolton	200,000							200,000														
Sewer to Burnham, Hegewisch & W. Hammond	500,000							500,000														
Extension Cal. Plant and Trickling Filter	2,000,000									$1,000,000	$1,000,000											
Total,		6,643,000																				
III. North Side Sewage Treatment Project:																						
North Side Treatment Plant	13,500,000		500,000	2,500,000	2,000,000	1,500,000	$3,700,000	3,300,000														
North Side Sewers	7,800,000			2,000,000	2,000,000	2,000,000	1,000,000	800,000														
Remodeling Lawrence Ave. Pumping Station	500,000				250,000	250,000																
Extension North Side Treatment Plant	2,000,000										1,000,000	$1,000,000										
Total,		23,800,000																				
IV. Industrial Wastes Treatment Project:																						
Corn Products Treatment Plant	1,800,000				100,000	800,000	900,000															
Stock Yards Treatment Pl. Demonstration	350,000				150,000	200,000																
Stock Yards, Pump. Sta. Sewers and Screens	1,000,000				500,000	500,000																
Stock Yards Treatment Plant	6,000,000									2,000,000	2,000,000	1,500,000	$ 500,000									
Total,		9,150,000																				
V. West Side Sewage Treatment Project:																						
West Side Treatment Plant (Imhoff)	10,900,000											000,000	1,800,000	$ 600,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,300,000	
West Side Sewers	13,300,000													2,000,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	600,000	500,000	
Total,		24,200,000																				
VI. Southwest Side Treatment Project:																						
Remodeling 39th & 73rd St. Pump. Stations	1,250,000			200,000	150,000								000,000	300,000								
Southwest Side Treatment Plant (Imhoff)	7,200,000																				$1,400,000	$1,450,000 per year
Southwest Side Sewers	9,400,000																		900,000	1,200,000	1,400,000	1,400,000 per year
Total,		17,850,000																				
VII. Miscl. Treat. Plants and Sewers:																						
Glenview Treatment Plant	61,000		61,000																			
Park Ridge Sewer Outlet	200,000			100,000	100,000																	
Park Ridge Sewer and Treatment Plant	550,000					200,000	200,000	150,000														
Northbrook Treatment Plant	60,000			60,000																		
La Grange Sewer and Treatment Plant	600,000			200,000	400,000																	
Sewer for Oak Forest, Posen and Robbins	300,000				300,000																	
Niles Outlet Sewer	75,000			75,000																		
Harvey Treatment Plant	500,000									250,000	250,000											
Schiller Park Treatment Plant	30,000											30,000										
Miscl. Treatment Plants and Sewers	10,640,000									350,000	350,000	540,000	600,000	000,000	600,000	600,000	000,000	600,000	000,000	600,000	600,000	800,000	800,000 per year
Total,		13,016,000																				
VIII. Miscellaneous Work:																						
39th Street Conduit	1,083,000		1,083,000																			
California Avenue Bridge	1,000,000		400,000	600,000																		
Cicero Avenue Bridge	1,000,000			100,000	500,000	400,000																
Crawford Avenue Bridge	1,000,000						500,000	500,000														
Harlem Avenue Bridge	1,000,000							100,000		000,000												
Roosevelt Road Bridge	600,000					400,000	200,000															
Regulating Works—Niagara and St. Lawrence Rivers	2,500,000				425,000	1,000,000	1,075,000															
Dredging Calumet River	1,000,000							500,000		500,000												
Highways	1,000,000		200,000	500,000	300,000																	
Lemont Outlet Sewer	30,000											30,000										
Total,		11,113,000																				
TOTAL	$106,322,000	$100,322,000	$5,582,000	$7,615,000	$7,425,000	$7,350,000	$7,575,000	$6,475,000	$5,000,000	$4,600,000	$4,000,000	$3,500,000	$3,500,000	$3,000,000	$3,000,000	$3,000,000	$3,000,000	$3,000,000	$3,000,000	$3,000,000	$3,000,000	$3,710,000 per year

Exhibit "E"

, POPULATION, ETC.

ɾ 36 CENTS NET; ALL SUBSEQUENT

MEMORANDA				
Assessed Valuation		Bonds		Year
Total (11)	Per Capita (12)	Maximum Capacity 3% (13)	Outstanding January (14)	
$1,915,000,000	$596	$53,500,000	$27,300,000	1923
1,965,000,000	598	57,450,000	33,004,000	1924
2,015,000,000	600	58,950,000	36,474,000	1925
2,065,000,000	603	60,450,000	40,744,000	1926
2,115,000,000	605	61,950,000	44,720,000	1927
2,170,000,000	608	63,450,000	50,046,000	1928
2,225,000,000	611	65,100,000	52,970,000	1929
2,280,000,000	615	66,750,000	56,544,000	1930
2,345,000,000	620	68,400,000	58,843,000	1931
2,400,000,000	623	70,350,000	60,370,000	1932
2,460,000,000	627	72,000,000	61,700,000	1933
2,520,000,000	630	73,800,000	63,230,000	1934
2,580,000,000	634	75,600,000	65,460,000	1935
2,645,000,000	639	77,400,000	67,340,000	1936
2,710,000,000	643	79,350,000	68,970,000	1937
2,780,000,000	650	81,300,000	71,250,000	1938
2,850,000,000	654	83,400,000	72,280,000	1939
2,920,000,000	660	85,500,000	73,960,000	1940
2,990,000,000	665	87,600,000	75,340,000	1941
3,065,000,000	671	89,700,000	76,350,000	1942
3,140,000,000	677	91,950,000	78,350,000	1943
3,220,000,000	683	94,200,000	79,050,000	1944
3,300,000,000	690	96,600,000	80,750,000	1945
		$99,000,000	$81,300,000	1946

.....$106,322,000
nd Opr..... 120,400,000
s..... 57,178,680

$283,900,680

Exhibit "F"

THE SANITARY DISTRICT OF CHICAGO
REVISED CONSTRUCTION PROGRAM
STATEMENT ESTIMATING REVENUE FROM TAXES AND BONDS AND COSTS, VALUES, POPULATION, ETC.

BASIS: 1923 AND 1924 COLLECTIONS ON A TAXING RATE OF 40 CENTS PER $100 VALUATION, GROSS, OR 36 CENTS NET; ALL SUBSEQUENT COLLECTIONS AT THE RATE OF 45 CENTS GROSS, OR 40½ CENTS NET.

Year	RECEIPTS			LIABILITIES				NEW CONSTRUCTION		MEMORANDA					Year
	From Direct Tax (1)	From Sale of 4% Bonds (2)	Total of 1-2 and 7-8 (3)	Bond Redemption (4)	Bond Interest (5)	Administration Maintenance and Operation (6)	Total of 4-5-6 (7)	Balances Available 3 minus 7 (8)	Construction Program (9)	Population (10)	Assessed Valuation Total (11)	Assessed Valuation Per Capita (12)	Bonds Maximum Capacity 3% (13)	Bonds Outstanding January (14)	
1923	$ 6,425,000	$ 8,000,000	$ 14,425,000	$ 2,296,000	$ 1,30[illegible]580	$ 3,100,000	$ 6,704,580	$ 7,720,420	$ 5,582,000	3,213,000	$1,915,000,000	$596	$53,500,000	$27,300,000	1923
1924	6,900,000	6,000,000	12,900,000	2,530,000	1,46[illegible]960	3,200,000	7,199,960	5,700,040	7,615,000	3,284,000	1,965,000,000	598	57,450,000	33,004,000	1924
1925	7,950,000	7,000,000	14,950,000	2,730,000	1,60[illegible]060	3,300,000	7,631,060	7,318,940	7,425,000	3,355,000	2,015,000,000	600	58,950,000	36,474,000	1925
1926	8,150,000	7,000,000	15,150,000	3,024,000	1,66[illegible]160	3,400,000	8,088,160	7,061,840	7,350,000	3,426,000	2,065,000,000	603	60,450,000	40,744,000	1926
1927	8,350,000	9,000,000	17,350,000	3,674,000	1,91[illegible]500	3,500,000	9,089,500	8,260,500	7,575,000	3,497,000	2,115,000,000	605	61,950,000	44,720,000	1927
1928	8,550,000	7,000,000	15,550,000	4,076,000	2,11[illegible]340	3,700,000	9,889,340	5,660,660	6,475,000	3,568,000	2,170,000,000	608	63,450,000	50,046,000	1928
1929	8,800,000	8,000,000	16,800,000	4,426,000	2,21[illegible]100	4,400,000	11,041,100	5,758,900	5,000,000	3,639,000	2,225,000,000	611	65,100,000	52,970,000	1929
1930	9,000,000	7,000,000	16,000,000	4,701,000	2,34[illegible]860	4,500,000	11,543,860	4,456,140	4,600,000	3,710,000	2,280,000,000	615	66,750,000	56,544,000	1930
1931	9,250,000	6,000,000	15,250,000	4,473,000	2,53[illegible]620	4,600,000	11,606,620	3,643,380	4,000,000	3,782,000	2,345,000,000	620	68,400,000	58,843,000	1931
1932	9,500,000	6,000,000	15,500,000	4,670,000	2,46[illegible]500	4,700,000	11,837,500	3,662,500	3,500,000	3,854,000	2,400,000,000	623	70,350,000	60,370,000	1932
1933	9,700,000	6,000,000	15,700,000	4,470,000	2,51[illegible]500	5,600,000	12,583,500	3,116,500	3,500,000	3,926,000	2,460,000,000	627	72,000,000	61,700,000	1933
1934	10,000,000	7,000,000	17,000,000	4,770,000	2,56[illegible]500	5,700,000	13,039,500	3,960,500	3,600,000	3,998,000	2,520,000,000	630	73,800,000	63,230,000	1934
1935	10,200,000	7,000,000	17,200,000	5,120,000	2,65[illegible]500	5,800,000	13,573,500	3,626,500	3,600,000	4,070,000	2,580,000,000	634	75,600,000	65,460,000	1935
1936	10,450,000	7,000,000	17,450,000	5,370,000	2,72[illegible]500	5,900,000	13,993,500	3,456,500	3,600,000	4,142,000	2,645,000,000	639	77,400,000	67,340,000	1936
1937	10,700,000	8,000,000	18,700,000	5,720,000	2,78[illegible]500	6,000,000	14,503,500	4,196,500	3,600,000	4,214,000	2,710,000,000	643	79,350,000	68,970,000	1937
1938	11,000,000	7,000,000	18,000,000	5,970,000	2,94[illegible]500	6,100,000	15,011,500	2,988,500	3,600,000	4,288,000	2,780,000,000	650	81,300,000	71,250,000	1938
1939	11,250,000	8,000,000	19,250,000	6,320,000	2,90[illegible]000	6,200,000	15,425,000	3,825,000	3,600,000	4,354,000	2,850,000,000	654	83,400,000	72,280,000	1939
1940	11,550,000	8,000,000	19,550,000	6,620,000	2,96[illegible]500	6,500,000	16,087,500	3,462,500	3,600,000	4,425,000	2,920,000,000	660	85,500,000	73,960,000	1940
1941	11,800,000	8,000,000	19,800,000	6,990,000	3,01[illegible]500	6,600,000	16,603,500	3,196,500	3,660,000	4,497,000	2,990,000,000	665	87,600,000	75,340,000	1941
1942	12,100,000	9,000,000	21,100,000	7,000,000	3,15[illegible]000	6,700,000	16,850,000	4,250,000	3,710,000	4,569,000	3,065,000,000	671	89,700,000	76,350,000	1942
1943	12,400,000	8,000,000	20,400,000	7,300,000	2,98[illegible]000	6,800,000	17,084,000	3,316,000	3,710,000	4,641,000	3,140,000,000	677	91,950,000	78,350,000	1943
1944	12,700,000	9,000,000	21,700,000	7,300,000	3,12[illegible]000	6,900,000	17,324,000	4,376,000	3,710,000	4,713,000	3,220,000,000	683	94,200,000	79,050,000	1944
1945	13,050,000	8,000,000	21,050,000	7,450,000	3,21[illegible]000	7,200,000	17,868,000	3,182,000	3,710,000	4,785,000	3,300,000,000	690	96,600,000	80,750,000	1945
									$106,322,000				$99,000,000	$81,300,000	1946
	$229,775,000	$171,000,000	$400,775,000	$117,000,000	$ 57,17[illegible]680	$120,400,000	$294,578,680	$106,196,320							

SUMMARY

RECEIPTS:

Taxes		$229,775,000
Bonds	$171,000,000	
Less retired	117,000,000	54,000,000
Deficit		125,680
		$283,900,680

LIABILITIES:

Construction	$106,322,000
Admin.-Maint. and Opr.	120,400,000
Interest on bonds	57,178,680
	$283,900,680

Compiled August 14, 1923.
H. M. CHRISTIE.

Exhibit "F"

has been planned. Two of the projects, the Calumet and the Des Plaines River, were well under way when the Sanitary District Act was amended in 1921, making it mandatory that sewage treatment works should be constructed at such a rate that, beginning with the year 1925 a population of at least 300,000 per year should be provided with sewage treatment until at least 60 percent of the present population is provided for. A brief description of the program, adopted by the Sanitary District, which will meet these requirements follows. Exhibit D is a tabulation showing the expenditures on sewage treatment projects, by years up to January 1, 1923. Exhibit E is a tabulation showing the proposed expenditures on all projects for the next twenty-three years, 1923 to 1945. Exhibit F is a tabulation showing the resources of the Sanitary District from 1923 up to 1945. This shows the possible receipts from taxes and sale of bonds; the necessary expenditures for interest on bonds, retiring of bonds, maintenance, operation and administration; and the balance available for new construction. This exhibit indicates the financial ability of the Sanitary District to carry out the construction program adopted.

I. Des Plaines River Sewage Treatment Project

The Des Plaines River Project is designed to treat the sewage of the towns draining into the Des Plaines River just west of Chicago. This covers an area of 18.5 square miles between North Avenue and Twenty-second Street and west of Harlem Avenue, having a present population of 39,000.

The Sewage Treatment Plant, located just west of the Des Plaines River and south of Twelfth Street, serves the towns of Maywood, Melrose Park, Forest Park, River Forest, the northern part of Oak Park and the U. S. Government's Speedway Hospital. In this plant the Activated Sludge Process is used. Construction was started on the project in 1918, delayed considerably by war conditions and completed and the plant put in operation in August, 1922.

Additional sewer connections are planned to be made in the very near future to bring the sewage of Broadview and Bellwood in from the west and Elmwood Park from the north. The cost of this project has been:

Des Plaines River Sewers	$1,458,218.46
Sewage Treatment Plant	1,441,835.01
Total to January 1, 1923	$2,900,053.47
Future connections and extensions	550,000.00

II. Calumet Sewage Treatment Project

The Calumet Project covers the entire region south of 87th Street, some 42.5 square miles, having a present population of 179,000.

This Project was started back in 1915 with the beginning of construction of the Calumet Intercepting Sewers. There are more than 13 miles of large sized sewers involved now completed except for approximately one-half mile of sewer, which is under construction. The Calumet Pumping Station was built 1917 to 1921. The Calumet Power Plant, a Diesel Engine plant for stand-by service for the pumping station, was built 1920 to 1922. The Calumet Sewers, Pumping Station and Power Plant although listed here as a part of the Calumet Treatment Project really have a double function. They also serve as feeders to the Calumet-Sag Channel in the general Dilution Project and if the Treatment Plant was not in operation they could be classified as a part of the Dilution Project. The Calumet Treatment Plant was begun in 1920, the sedimentation tanks completed and put in operation in September, 1922, and the tanks for the Activated Sludge Process put in service in May, 1923. The Ninety-fifth Street Pumping Station will be constructed within the next year, completing the entire Calumet Project except for future extensions.

The Sewage Treatment Plant, located at 125th Street and Cottage Grove Avenue, is now treating over half of the sewage of the Calumet district. In this plant there are 30

units of double deck Imhoff tanks in which the sewage is settled and 2 units in which the Activated Sludge Process is used. Sedimentation alone gives partial treatment (approximately 33%). There is one trickling filter unit to give complete treatment to the sewage passing through one of the Imhoff tank units. Experiments on a real working scale are now being conducted, comparing Sedimentation plus sprinkling filter and Activated Sludge, to determine the policy of future expansion at this plant as well as knowledge for design of the larger plants soon to be built in other sections of the city.

Future extensions of this project, to be made when the population justifies them, include sewers to connect Burnham, Hegewisch, West Hammond, Dolton, Riverdale and Blue Island to the Treatment Plant; also additions of trickling filter units to the plant itself.

The construction costs have been:

Calumet Intercepting Sewers	$ 5,049,400.61
Calumet Pumping Station	1,499,402.02
Calumet Power Plant	1,164,458.59
Ninety-fifth Street Pumping Station	5,496.07
Calumet Treatment Plant	6,124,866.62
Total to January 1, 1923	$13,843,623.91
Estimated cost to complete	3,518,000.00
Future extensions	3,125,000.00

III. North Side Sewage Treatment Project

The North Side Project covers the district lying north of Fullerton Avenue, Chicago, extending to the north line of Cook County, an area of approximately 62 square miles, with a population (1927) of 737,000. Construction on this project which embraces the whole North Side of the City and the North Shore towns is now under way, work having begun in January, 1922. The Treatment Plant is the third of the large treatment plants to be constructed by the Sanitary District and will be the largest Activated Sludge plant in the world. A tract of 180 acres of land was acquired in

1921, located just west of the North Shore Channel and north of Howard Avenue, to be used as the site for this plant. A contract for the construction of the aeration and settling tanks, with the necessary conduits and pipe work, was entered into on August 9, 1923, in the amount of $5,602,635.50. Other contracts for work on this plant, such as construction of a pumping station, grit chambers, screen house, blower house, laboratory, machinery, etc., will be let in the near future. The estimated cost of the Treatment Plant is $13,500,000.00.

The system of intercepting sewers leading to the North Side Treatment Plant involves the construction of about 14 miles of sewers ranging in size from 4 feet to 18 feet in diameter. Sewers will be constructed along both sides of the North Branch of the Chicago River and the North Shore Channel, with one branch leading over from the Lawrence Avenue Pumping Station. One branch of this sewer system, four miles long, leading down from the North Shore Sewer at Wilmette, along the west bank of the North Shore Channel to the site of the treatment plant, was constructed in 1922. The estimated cost of the balance of the system of collecting sewers is $10,300,000.00. The date of completion of the project has been set for the year 1928.

The total expenditures on this project have been:

North Side Sewer	$2,023,662.99
Treatment Plant (site, etc.)	304,394.55
Total to January 1, 1923	$2,328,057.54
Estimated cost to complete	$23,800,000.00

IV. Industrial Wastes Treatment Project

The Industrial Wastes Treatment Project covers first, the treatment of the wastes of the Stock Yards and Packingtown, and second, the treatment of the wastes of the Corn Products Company at Argo.

Packingtown and the Stock Yards occupy an area of only 1.5 square miles, but the strong trade wastes from this small district are equivalent to the domestic sewage of 1,030,000 people. Preliminary plans have been prepared for a plant

to treat this sewage and a site, not entirely satisfactory because of its small size, has been acquired. Negotiations are under way with the packing interests relative to the proportional payments to be made for construction and operation. The construction cost is estimated at $7,350,000.00 and the date of completion has been set at 1926 for the first unit and 1932 for the final unit.

The wastes of the Corn Products Company at Argo are equivalent to the domestic sewage of 380,000 people, and are concentrated in one main sewer. Experiments have been practically completed on these wastes and in the near future a plant will be planned for their treatment. The date for completion is set for 1927. The construction cost is roughly estimated at $1,800,000.00.

The industrial waste program also covers the taking care of other wastes, principally from tanneries located on the North Branch of the Chicago River.

V. West Side Sewage Treatment Project

The West Side Project covers an area of 57.5 square miles lying between Fullerton Avenue and Thirty-first Street and extending east from Harlem Avenue to the Lake Front, including the Loop District. This is by far the most important sewage treatment project of the Sanitary District, on account of its size, the population involved being now 1,340,000. Negotiations are now under way for a site for the treatment plant, a small tract of land having already been acquired. One intercepting sewer, the Fifty-second Avenue sewer, has been built at a cost of $283,379.50, forming one of the branches of the collecting system. Some 16 miles of large sized sewers need to be built, located mostly in the busy part of the city. Preliminary layouts have been made on this Project and surveys will be started within the next year. The estimated cost is $24,200,000.00 and the time of completion is set at 1940.

VI. The Southwest Side Sewage Treatment Project

The Southwest Side Project covers all that portion of the city lying south of Thirty-first Street and of the Drainage Canal and north of Eighty-seventh Street. The area of this region is 59.0 square miles and the population is now 910,000. Some parts of this district are now sparsely settled, and it was deemed advisable to make this project the last one on the program. Studies are being made of changes in certain sewers in this district and all new sewer construction is planned with the ultimate view of collection in one spot for treatment. The cost of this project is estimated at $17,850,000.00 and the date of completion is set at 1945.

VII. Miscellaneous Sewage Treatment Projects

In addition to the six major sewage treatment projects outlined above a number of small projects have been planned for the outlying towns and villages. The Sanitary District includes 49 incorporated cities and villages outside of Chicago, many of which are so located as to make it economical to solve their problems separately.

The building of sewage treatment plants was begun by the Sanitary District with the construction of a small settling tank and trickling filter plant for the isolated village of Morton Grove in 1914. This plant serves a population of only 1,200 and has been of more value for experimental purposes than for any real relief to the sanitary situation. The cost of its construction was $65,964.31. Other small plants have cost $1,942.10 up to January 1, 1922.

Following is a list of small projects, now under consideration, with an estimate of cost of each Others will be required as the suburban population increases.

Glenview Treatment Plant (under construction)	$ 61,000.00
Treatment Plant and Sewers for La Grange, Brookfield and La Grange Park	600,000.00

Northbrook (Shermerville) Treatment Plant	$ 60,000.00
Sewer for Oak Forest, Posen and Robbins	300,000.00
Park Ridge Sewer Outlet	200,000.00
Niles Outlet Sewer	75,000.00
Treatment Plant for Upper Des Plaines Towns	550,000.00
Harvey Treatment Plant	500,000.00
Schiller Park Treatment Plant	30,000.00
Miscellaneous Plants and Sewers (Future)	10,640,000.00
Total	$13,016,000.00

SUMMARY OF COSTS OF SEWAGE TREATMENT

Construction To January 1, 1923

Experiments	$ 256,967.43
Des Plaines River Project	2,900,053.47
Calumet Project	13,843,623.91
North Side Project	2,328,057.54
West Side Project	283,397.50
Miscellaneous Small Projects	67,906.41
Bare Construction Cost	$19,697,988.26
Administration, legal expense, clerical expense, etc	1,197,498.24
Interest on bonds for Construction	4,601,165.08
Total Expenditures on Sewage Treatment	$25,478,651.58

Future Construction Program (1923-1924)

Des Plaines River Treatment Project	$ 550,000.00
Calumet Treatment Project	6,643,000.00
North Side Treatment Project	23,800,000.00
Industrial Wastes Treatment Project	9,150,000.00
West Side Treatment Project	24,200,000.00
Southwest Side Treatment Project	17,850,000.00
Miscellaneous Small Treatment Projects	13,016,000.00
Total	$95,209,000.00
Ultimate Total for Sewage Treatment	$120,687,651.58

DILUTION REQUIRED, 1923 to 1945

Using a dilution ratio of 3.33 c. f. s. of fresh water for each 1,000 people whose wastes are carried untreated into the Main Drainage Canal, there is now required (1923) a diversion of 15,500 c. f. s. The present status is

Population Sanitary District (1923)		3,213,000
Stock Yards Wastes, equivalent to		1,030,000
Corn Products Wastes, equivalent to		380,000
Miscellaneous Wastes, equivalent to		150,000
Total		4,773,000
Less population treated		
Morton Grove	1,200	
Calumet Plant (Equivalent)	72,800	
Des Plaines River Plant	39,000	113,000
Equivalent population not treated		4,660,000
Diversion needed for same		15,500 c. f. s.

Even though the diversion of this amount should be permitted it could not be used because the capacity of the Dilution System is but 10,000 c. f. s. The figures indicate that the Sanitary District is behind in its sewage treatment schedule. It is behind, because conditions during and after the World War not only materially increased costs, but slowed construction while Chicago's population increased at its regular rate. The program adopted for the years 1923 to 1945, providing for the expenditure of $106,322,000 on new construction will use up all of the resources of the Sanitary District, but it will enable it to catch up in the matter of sewage disposal with the growth of the community. The population of the Sanitary District is increasing at the rate of 71,000 per year. It is not a simple little proposition to take care of the sewage of a community which adds to its population the equivalent of a city like Washington once in every six years.

Exhibit G is a tabulation showing the amount of water estimated at the various times over the next 23 years to dilute the sewage of the Sanitary District in accordance with its charter while the treatment projects are being

WATER NEEDED FOR DILUTION OF SEWAGE 1923 TO 1945 DURING CONSTRUCTION OF TREATMENT PLANTS

Year	Population of Sanitary District	Industrial Wastes Equivalent Population	Total Equivalent Population	Population Treated	Population Not Treated	Dilution Requirement. C. F. S.
1923	3,213,000	1,560,000	4,773,000	113,000	4,660,000	15,500
1924	3,284,000	1,580,000	4,864,000	118,000	4,746,000	15,800
1925	3,355,000	1,600,000	4,955,000	123,000	4,832,000	16,100
1926	3,426,000	1,620,000	5,046,000	128,000	4,918,000	16,400*
		CORN PRODUCTS TREATMENT PLANT COMPLETED 1927 NORTH SIDE TREATMENT PLANT COMPLETED 1928				
1928	3,568,000	1,660,000	5,228,000	1,291,000	3,937,000	13,125
		SPRINKLING FILTERS ADDED TO CALUMET PLANT 1929-1930				
1930	3,710,000	1,700,000	5,410,000	1,485,000	3,925,000	13,075
		STOCKYARDS TREATMENT PLANT COMPLETED 1932				
1932	3,854,000	1,740,000	5,594,000	2,679,000	2,915,000	10,000**
1935	4,070,000	1,800,000	5,870,000	2,820,000	3,050,000	10,175
1938	4,283,000	1,860,000	6,143,000	2,955,000	3,188,000	10,625
		WEST SIDE TREATMENT PLANT (SEDIMENTATION TANKS) COMPLETED 1940				
1940	4,425,000	1,900,000	6,325,000	3,562,000	2,763,000	10,000**
1943	4,640,000	1,960,000	6,600,000	3,712,000	2,888,000	10,000**
		SOUTHWEST SIDE TREATMENT PLANT (SEDIMENTATION TANKS) COMPLETED 1945				
1945	4,783,000	2,000,000	6,783,000	4,252,000	2,531,000	10,000**

*Maximum Demand. **Covers floating and tributary population not included in above table.

Exhibit "G"

constructed. In this table the rate of dilution is taken at 3.33 c. f. s. of water per 1,000 population. No account is taken of the sewage from the towns in the northwest corner of Indiana draining into the Sanitary District by way of the Calumet River. These towns had a population of 127,000 in 1920. Neither has been considered the transient or floating population of Chicago, amounting to over 100,000.

METERING OF WATER SUPPLY

Within the past few months a movement has been started in Chicago backed by Engineering Societies and other Civic Organizations, which it is hoped will lead to the metering of water. The pumpage is now approximately 275 gallons per capita per day, which is obviously much more than is necessary. Metering of water would be of great value to the Sanitary District in carrying out its sewage treatment program as it would surely cut down the amount of water used. It is difficult to compute what the exact saving would be, but it is estimated that metering would save 25 per cent of the construction costs of the West Side and the Southwest Side Projects. The North Side Project is already under way and will be completed before water meters could be installed, so no immediate saving can be assumed under any condition. However, metering would prolong the life of the present construction on this project by about 10 years, that is it will push the time that additions are needed in the capacity of the plant 10 years farther in the future and eventually effect a saving of 25 per cent. It would decrease the annual cost of the whole program about $2,000,000.00 after 1945, the date of final construction.

REGULATING WORKS FOR GREAT LAKES

It has been estimated that a diversion of 10,000 c. f. s. from Lake Michigan at Chicago would have a maximum lowering effect on Lakes Michigan and Huron of five and one-half (5½) inches. Its effect on the levels of Lakes

Erie and Ontario would be a lowering of approximately the same amount. To compensate for any lowering effect caused by the operation of the Chicago Drainage Canal or of the Dilution Project, the Sanitary District offers to pay for the construction of Regulating Works in the Niagara River at the outlet of Lake Erie and in the St. Lawrence River at the outlet of Lake Ontario. It does not suggest regulating works of any particular type, but will collaborate in any scheme which the United States Engineers think advisable, and will design for comparison and study various types of such works.

Preliminary designs of regulating works and an analysis of their use indicate that the average level of Lake Erie can be raised fourteen inches in a decade of dry years and twelve inches in a decade of normal years and at very low stages the level of Lake Erie can be safely raised at least 19½ inches. This is the time when water is most needed for navigation and water power. The result of operation under the low stage conditions is the real test of the value of the proposed regulating works. This same study indicates that the level of Lake Ontario can be raised twenty-one inches in a decade of dry years and twelve inches in a decade of normal years. These regulating and compensating works consist of movable dams, placed in a portion of the outlets of the lakes which, when closed, throttle the outlets and when opened permit a higher outflow than normal due to the higher lake stage.

The feasibility of safely and certainly regulating lake and river levels cannot be denied. The estimated cost of constructing suitable Regulating Works is $2,500,000.00.

More details regarding the feasibility and the benefits of the use of Regulating Works can be found in Appendix "B" at the end of this report. Appendix "B" is a reprint of **A REVIEW,** made in December, 1921, by Francis C. Shenehon, Consulting Engineer, of all the circumstances surrounding the **Withdrawal of Water from the Great Lakes**

System by the Sanitary District of Chicago. Mr. Shenehon is a Consulting Hydraulic Engineer of note, whose connection for many years with the United States Lake Survey, has rendered him particularly well qualified to discuss this subject.

MISCELLANEOUS WORK

In addition to the work under way and planned by the Sanitary District to carry out the program of Sewage Treatment, there are a number of items of construction which must be done for the public welfare to compensate for the inconvenience caused by past construction. Among these are bridges across the Main Drainage Canal, a portion of the cost of a bridge across the Chicago River at Roosevelt Road (Twelfth Street), highways along the channels to give access to dock property, etc. Another job is the Thirty-ninth Street Conduit Extension, previously mentioned, now under construction. An important item is the dredging of the Little Calumet River between Lake Calumet and Blue Island to a navigable depth of 12 feet for a width of 90 feet, completing the link between the Calumet Sag Channel and the United States Government's project in the Calumet River. It is also proposed to pay the cost of construction of regulating works at the outlets of Lake Erie and Ontario to restore lake levels.

A summary of the miscellaneous work now pending is:

California Avenue Bridge (under construction)	$ 1,000,000.00
Crawford Avenue Bridge	1,000,000.00
Cicero Avenue Bridge	1,000,000.00
Harlem Avenue Bridge	1,000,000.00
Roosevelt Road Bridge	600,000.00
Lemont Outlet Sewer	30,000.00
Thirty-ninth Street Conduit Extension (under construction)	1,983,000.00
Dredging Little Calumet River	1,000,000.00
Highways	1,000,000.00
Regulating Works for Great Lakes	2,500,000.00
Total	$11,113,000.00

FLOOD RUN-OFF CHICAGO RIVER DRAINAGE AREA

The drainage area of the Chicago River is 307 square miles, of which 219 square miles drains into the North Branch and 88 square miles into the South Branch. A flood run-off of 13.6 cubic feet per second per square mile over this area will exceed 4,167 cubic feet per second. Such a run-off occurs from seven to eight times per year under present conditions, with 156 square miles sewered, and 151 square miles not sewered. As the built up sections of the district increase, the sewered area will increase and the run-off rate will increase.

The run-off from the drainage area of the Chicago River

exceeds 4,167 c. f. s. from 7 to 8 times per year
exceeds 5,000 c. f. s. from 5 to 6 times per year
exceeds 7,500 c. f. s. from 3 to 4 times per year
exceeds 9,500 c. f. s. about 1 time per year

With a definite maximum limit established for the diversion from Lake Michigan, materially less than 10,000 c. f. s. there would be many times when the Chicago River would reverse and flow into the Lake. On March 17, 1919, due to a flood in the Des Plaines River, combined with a flood from the Chicago River water shed, it was necessary to flow 15,560 c. f. s. through the Controlling Works at Lockport for a short interval to prevent a reversal of the Chicago River. Two days later, on March 19, 1919, a rate of 15,200 c. f. s. was necessary. On these two days, 3,850 c. f. s. was spilled from the Des Plaines River into the Main Channel at Willow Springs. The capacity of the Des Plaines River Improvement Channel through Joliet was taxed to its limit of 25,000 c. f. s. In this flood and in another one of almost the same intensity, from May 3rd to 6th, 1919, the worst operating condition in the past decade was reached. The source of flood supply was probably

From North Branch Chicago River	4,700 c. f. s.
From Chicago (Central and West)	3,000 c. f. s.
From South Fork of South Branch	1,900 c. f. s.
From Sag Valley	2,400 c. f. s.
Total in Main Channel	12,000 c. f. s.
From Des Plaines River	13,000 c. f. s.
Total through Joliet (capacity)	25,000 c. f. s.

An unusually heavy rain, 2.68 inches, fell during the early morning hours of August 11, 1923, and caused the most serious reversal in the Chicago River which has happened since 1900. Complete details of this matter are given in an appended report. (See Appendix "C.") The flow in the Drainage Canal, measured at Lockport, was approximately 10,000 c. f. s. from 9:00 p. m. August 10th, till 5:00 a. m. August 11th and 4,340 c. f. s. from 5:00 a. m. till 9:00 a. m. August 11th, an average over these twelve hours of 8,110 c. f. s. Reversal of the Chicago River was observed about 9:00 a. m., the flow was increased, averaging approximately 13,850 c. f. s. from 9:00 a. m. till 1:00 p. m., when flow from the lake was re-established. A flow averaging 12,000 c. f. s. from 1:00 p. m. until 7:00 p. m. was necessary to hold the Chicago River from reversing again. This is an example of what might happen during any heavy rain unless the flow established in the Chicago River is more than the run-off due to the rainfall. Rains causing run-offs up to 10,000 c. f. s. occur on an average of approximately once a year in Chicago.

The sewers in Chicago, between Howard Avenue on the north and Eighty-seventh Street on the south, discharging into the Chicago River and Drainage Canal, have a total flow capacity of 10,500 c. f. s. when running full with hydraulic slopes parallel to the bottom grades of the sewers. There are few of these same sewers which do not operate under a head and discharge much more during only moderate rains.

Assuming average rates of run-off as 0.10 from the 151 square miles of area not sewered and 0.50 from the 156 square miles of area sewered, gives an average rate of 0.30 from the total watershed of 307 square miles. An inch per hour of rainfall equals 1 c. f. s. per acre or 640 c. f. s. per square mile. On this basis, in the Chicago River Watershed, a long continued rain of

0.05	inch per hour will run off.....	2,947 c. f. s.
0.071	inch per hour will run off.....	4,167 c. f. s.
0.10	inch per hour will run off.....	5,894 c. f. s.
0.15	inch per hour will run off.....	8,841 c. f. s.
0.20	inch per hour will run off.....	11,788 c. f. s.

The velocity in the Drainage Canal, or any other channel, for a flow 10,000 c. f. s. is 2.4 times the velocity for a flow of 4,167 c. f. s. If the water cross-section remain constant, the fall from Lake Michigan to Lockport, 36 miles, or for any other distance, necessary to cause a flow of 10,000 c. f. s. is 2.4 squared, or 5.76 times the fall necessary to cause a flow of 4,167 c. f. s. The lesser flow, requiring less slope and causing a greater water cross-sectional area, will raise this ratio to approximately 1 to 6 in place of 1 to 5.76. With the surface of Lake Michigan at 0.0 c. c. d., the water surface in the Main Drainage Canal at Lockport must be at approximately—1.2 c. c. d. to produce a flow of 4,167 c. f. s. through the Chicago River and Calumet-Sag Channel. The water surface at Lockport must be at approximately—7.0 c. c. d., to produce a flow of 10,000 c. f. s.

It is not uncommon for the surface level of Lake Michigan at Chicago to drop as much as six inches due to a change in the direction of the wind or a change in the barometer. Such a change can happen in an hour and if the Drainage Canal was flowing only 4,167 c. f. s. at such a time the upper 40 per cent or 14 miles of the Channel and River would be above lake level. This would cause flow into Lake Michigan, principally from the North Branch of the River. If the Drainage Canal was flowing 10,000 c. f. s. at such a time only the upper 7 per cent or 2.5 miles of the River would be above lake level. It requires a lapse of time of three or four hours for the effect of a change made in the flow in the Canal at Lockport to be even noticed in the upper Chicago River; at least eight hours to cause any considerable change in the condition of the Chicago River and about twenty-four hours for the full effect of the change to be established in the River. For this reason it is necessary to have a safe flow established at all times. The difference between 4,167 c. f. s. and 10,000 c. f. s. is the difference between almost constant danger of pollution to the water supply and reasonable safety. The actual time required,

as mentioned above, to alter flow conditions in the Chicago River by changing the flow through the Lockport Controlling Works was determined by a series of elaborate experiments made in February, March and September, 1914.

A flow of 4,167 c. f. s. would mean constant danger of pollution to the water supply. As long as the capacity of the Drainage Canal remains at approximately 10,000 c. f. s., as at present, there would always be a chance to prevent pollution by increasing the flow in time to take care of heavy rains. But with this low flow (4,167 c. f. s.), maintained practically all the time over a period of a few years, such silting would take place in the Chicago River and Drainage Canal as to give the channels a capacity of only 4,167 c. f. s. Then danger of pollution would become certainty of pollution at the first heavy rain because of the impossibility of flowing a sufficient quantity of flood water through the channel of small capacity.

NEED OF DIVERSION AT CHICAGO

The Sanitary District requires a diversion of 10,000 cubic feet per second from Lake Michigan at Chicago for the following reasons:

First: It has, at an expense of $97,593,669.98, constructed a system of canals, auxiliary sewers and pumping stations and has made improvements in the Chicago River and Des Plaines River, completing in every detail a project that has a capacity of 10,000 c. f. s. for the dilution of sewage, a project that will provide for 3,000,000 people. The capacity of the project as designed and built was that specified in the Act of the General Assembly of Illinois of May 29, 1889. The construction of the Drainage Canal was given the greatest publicity. It was inspected by eminent engineers, representatives of the Federal Government and of Foreign Powers, delegations from various states of the Union and from civic bodies. All phases of the project were widely discussed in the public press and in

technical journals. The construction of the North Shore and the Calumet-Sag Channels was given the same publicity. The Main Drainage Canal is the most expensive and the most important link in the Waterway from the Great Lakes to the Gulf of Mexico. Its capacity of 10,000 c. f. s. makes it a help and not a hindrance to navigation. While it was being constructed no hint was given from any source that it could not be used to its full capacity; that it should be completed and rank almost as one of the wonders of the world and then be used to only 41.67 per cent of its capacity. This dilution project has cost the people of the Sanitary District in round figures one hundred millions of dollars, a per capita expenditure which if applied to the whole United States would raise a sum sufficient to build twelve Panama Canals, or retire the Third Liberty Loan. The taking away of the right to divert 10,000 c. f. s. and use this project to its full capacity will destroy this investment and will work an unreasonable hardship on the people of this community.

Second: Although the Sanitary District has already expended $25,478,651.58 on the construction of sewage treatment projects and plans to spend $95,209,000.00 more for the same purpose in the next twenty-three years, a diversion of more than 10,000 c. f. s. is needed to properly dispose of the sewage of this community during this construction period and a diversion of at least this amount will be needed at the end of the period to provide for the 2,531,000 and more of people who will live here then and whose wastes must be treated by dilution in the present sewage treatment program. Another consideration is the fact that artificial sewage treatment is not 100 per cent efficient and not 100 per cent sure. With 10,000 c. f. s. of water available for use to dilute sewage no harm could come to the community should a treatment plant temporarily cease to function. This diversion is needed to take care of the filth which will be washed off streets during rains, the treatment plants not being designed to handle

the extra sewer flow caused by rains, also to handle sewage originating in certain areas where it is not feasible to collect it for treatment.

Third: A diversion of 10,000 c. f. s. is needed to prevent the Chicago River from reversing and flowing into Lake Michigan during a heavy rain. With a flow slightly less than this amount, past records indicate that the river would reverse on an average of once a year. With lesser flows the number of reversals would be more frequent and a flow as low as 4,167 c. f. s. would permit a reversal seven or eight times per year, or every time there was an ordinarily hard rain. The rain of August 11, 1923, demonstrated that the Chicago River would reverse during a heavy rain with practically the full flow established in the Drainage Canal. In this particular case it required a flow of approximately 13,800 c. f. s. for four hours to change the flow back from the lake to the river and a flow of approximately 12,000 c. f. s. for six hours more to hold it there. If the water supply of Chicago is to be protected from possible contamination by sewage, it is necessary that a flow of 10,000 c. f. s. be maintained in the Drainage Canal and even this should be increased during the exceptionally heavy rains.

CONCLUSION

The past and future expenditures in connection with sewage disposal and the incidental work arising therefrom in the Sanitary District of Chicago are summarized in the following table:

Costs of Past Construction

Dilution and Navigation Project, capacity 3,000,000 people with 10,000 c. f. s. diversion	$ 97,593,669.98
Water power development	1,395,712.75
Sewage Treatment	25,478,651.58
Total to January 1, 1923	$123,072,321.56

Future Construction (1923-1945)

Sewage Treatment Projects.....	95,209,000.00
Miscellaneous Work.....	11,113,000.00
Total Construction.....	$229,394,321.56

These lavish expenditures demonstrate that the Sanitary District has done and will do all that any community can do to protect the health of its inhabitants. Its past record is a record of progress. Its future program provides for as much new work as any organization can promise to perform and carry out. It pledges all its resources for the next twenty-five years to preserve the health of five millions of people. The value of the lives saved by keeping pure and undefiled the waters of Lake Michigan more than compensates for any damage caused by temporarily slightly lowering lake levels. In addition the great contribution of the Sanitary District in aid of navigation is an element to be given great consideration.

APPENDIX A

HISTORICAL FACTS REGARDING DIVERSION AT CHICAGO

Events Preceding the Construction of the Drainage Canal

The construction of the Main Drainage Canal of the Sanitary District of Chicago was not without precedent and not without the sanction of the Federal Government.

When Illinois was admitted to the Union the question of constructing a waterway between the Lake Michigan and Mississippi River watersheds was under consideration. In 1822, the Congress of the United States recognized the value of building a canal **"connecting the Illinois River with the southern bend of Lake Michigan"**, and on March 30 1922, Congress passed an Act providing for such a canal and donating to the State of Illinois certain lands to aid in the construction. The State did not meet with the requirements of the Act and it expired through lapse of time.

Congress again, on March 2, 1827, passed an Act providing for the construction of a canal **"to unite the waters of the Illinois River with those of Lake Michigan"** and donating to the State a certain amount of land to assist in the construction of the canal. The State of Illinois met with the requirements of this Act, received the land and provided for the construction by an Act of the General Assembly passed January 9, 1836. Section 16 of this Act provided that the canal should **"be supplied with water from Lake Michigan and such other sources as the Canal Commissioners may think proper."**

The Supreme Court of the United States, in **Missouri vs. Illinois,** 200 U. S. 495-526, in speaking of the effect of the action of Congress and of Illinois in providing for the construction and operation of this canal, said: **"it is enough to say that Illinois brought Chicago into the Mississippi watershed in pursuance not only of its own statutes but also of the Acts of Congress of March 30, 1822 * * * * * * and March 2, 1827 * * * * * * the validity of which is not disputed."**

It is obvious that Congress intended, by the Acts mentioned, and Illinois understood, that water might be withdrawn from Lake Michigan for the purpose of creating a stream and waterway from Lake Michigan

to the Desplaines and Illinois Rivers. There was no limitation as to the amount of the withdrawal. The waterway and stream having been created by the sovereign authorities of the United States and the State of Illinois, it may be presumed that it was intended it should be utilized in every way that such a waterway or stream might serve the people of the Country and the State.

A waterway from Lake Michigan to the Illinois River, the Illinois and Michigan Canal, was completed in 1848. Shortly thereafter, pumps were installed at Bridgeport, the northern terminus of the canal, to withdraw water from the South Branch of the Chicago River for the canal's operation and also for the purpose of cleansing to some extent, the river which was even then polluted by sewage.

In 1871, the Illinois and Michigan Canal was enlarged and deepened across the summit from Chicago to Lockport, to withdraw a greater amount of water from the Chicago River. This produced the first diversion of water from Lake Michigan at Chicago by gravity and was the forerunner of the diversion which took place through the Chicago Drainage Canal some twenty-nine years later. The expense of deepening the Illinois and Michigan Canal and producing a gravity flow was borne by the City of Chicago, pursuant to legislative authority and power granted for the purpose of relieving to some extent the filthy conditions then existing in the Chicago River and the pollution of the Lake Michigan water supply because of the discharge of sewage into the Lake by way of this stream.

Under the Rivers and Harbor Act of 1875, Colonel J. M. McComb of the Corps of Engineers of the United States Army, made a report to Congress dated January 25, 1875, concerning the improvement of this waterway, in which he stated: **"The improvement of the Illinois and Michigan Canal involves the further cutting down of the summit level and enlarging the waterway so as to afford an unfailing supply of water from Lake Michigan for the improved Illinois River."** Subsequently, many reports were made by the United States Army engineers pursuant to Rivers and Harbors Acts of Congress along substantially the same lines.

In 1884, conditions regarding the pollution of the Chicago River and the water supply having grown worse, new pumps were constructed and put in operation at Bridgeport to withdraw from the River not less than 60,000 cubic feet per minute. The cost of installing and operating these pumps was borne by the City of Chicago under authority from the Illinois State Legislature.

Chicago was growing so rapidly and conditions of pollution of the water supply through the discharge of sewage into Lake Michigan both directly and by way of the Chicago River became so critical that the people of the community set about to thoroughly solve the problem of sewage pollution and water supply. A Drainage and Water Supply Commission was created, composed of eminent engineers. This Commission made a report in 1887 which led to the creation of the Sanitary District in 1889, the construction of the Main Drainage Canal, 1892-1900, and the diversion of water from Lake Michigan through the Drainage Canal beginning in 1900.

Permits for Diversion from Lake Michigan at Chicago

The maximum run-off of the Chicago River Drainage Area and thus the maximum flow of the Chicago River, was estimated and considered to be at the time the Sanitary District's Main Channel was projected, 10,000 cubic feet of water per second. Thus the main channel of the District was constructed to a maximum capacity of that amount. Otherwise it would not at all times keep the Chicago River reversed and flowing away from Lake Michigan, which was fundamentally necessary in order to prevent pollution of the water supply at times of heavy rain.

A permit was issued on May 8, 1899, by the Secretary of War (Gen. Alger), authorizing and permitting the Sanitary District to open the main channel which had theretofore been completed, subject to two primary conditions:

(1) If Congress should act in the premises by legislation, then the permit should have no further force or effect.

(2) If current were created by the withdrawal of water from Lake Michigan unreasonably obstructive to navigation in the Chicago River, then the Secretary of War reserved the right to modify it.

There has been no action of Congress. There was, however, a current created in the Chicago River because of its then shallowness, narrowness and tortuousness, being only 17 feet deep and less than 100 feet wide at different points. For this reason the Secretary of War later modified the original permit of May 8, 1899, reducing the amount of the withdrawal. It follows that had there been no current created and had the Chicago River Channel been as wide and as deep as it was later created, there would have been no modification of the amount of the withdrawal, and the Sanitary District would be now withdrawing the amount of water that it asks and requires, without Federal objection or controversy.

However, on April 9, 1901, because of objections to current in the Chicago River and for that express reason, the Secretary of War modified the original permit to 200,000 cubic feet per minute (3,333 C. F. S.). Various other modifications were made, and finally in 1903 the District was directed not to withdraw more than 250,000 cubic feet per minute, or 4,167 cubic feet per second.

However, while these modifications of the original permit were being made because of objections to current in the Chicago River by navigation interests there, the Sanitary District, pursuant to permits of July 11, 1900, and permit of 1902, had made plans for the deepening and widening of the Chicago River to 26 feet in depth and 200 feet in width at all points. Condemnation proceedings to obtain land for the widening had to be tried. About the year 1903, when the last modification was made, the District commenced the work of deepening and widening the River, pursuant to the Federal permits, in order to create a channel of such flowage capacity that a current would not be created obstructive to navigation by taking through that channel water from Lake Michigan required to operate the Main Channel to its full capacity. This work extended over a period of years and necessarily required considerable time for its completion, as it was necessary to dredge the entire river channel, take out immense quantities of earth to widen the river, re-place old center pier bridges with new and modern type bascule bridges. So the work did not reach its practical completion until about the year 1912. The Chicago River improvement, for deepening and widening the South Branch cost the Sanitary District $12,472,381.54.

From the above record the officials of the Sanitary District were justified in assuming that the restrictions on flow through the Chicago River were made only in the interest of navigation in the River; and that when the river improvement was completed which would permit the maximum flow through the Chicago River with a current of not more than one and one-quarter miles per hour, this improvement could be used to its capacity. Why else should they have gone ahead with an expenditure of twelve and a half millions of dollars on this improvement? The Chicago River as it was twenty years ago could carry 4,167 C. F. S. without an excessive current.

The reason for the modification of the original permit having been removed, it was necessarily assumed that the modification would have no further force or effect, and that the original permit as to its full extent would be recognized. Therefore the Sanitary District on February 5, 1912, made application to the Secretary of War for the withdrawal of the modification and the recognition of the original

permit by again issuing one for the withdrawal of 10,000 cubic feet per second. On May 8, 1913, the Secretary of War, however, refused on the principal ground that he was without authority to authorize anything that would amount to an obstruction to navigation and Congress only had that authority.

Diversions at Niagara

In the Boundary Waters Treaty between the United States and Great Britain, ratified May 5, 1910, diversions in cubic feet per second are allotted to each country **"of the waters of the Niagara River above the Falls from the natural course and stream thereof"** as follows:

United States in New York State	20,000
Canada in Province of Ontario	36,000

These are in round numbers the figures that were recommended by the International Waterways Commission in the negotiations which preceded the making of the Treaty. This Commission had recommended 18,500 c. f. s. for the American diversion and 34,200 c. f. s. for the Canadian diversion, exclusive of the diversion for the Welland Canal which was 1,800 c. f. s.

The views of the Dominion of Canada in regard to the diversions at Chicago and in and near the Niagara River is given in a report of the Canadian Section of the International Commission, dated April 25, 1906, to the Minister of Public Works. The following are extracts from the report:

> "At Chicago, the Americans have built a drainage canal which, when in full operation, will use about 10,000 cubic feet of water per second."
>
> "As the diversion from Lake Michigan to the Mississippi River is of a much more serious character than the temporary diversions from the Niagara River, it is felt that the amount of water to be taken on the American side of the Niagara River should be limited to 18,500 cubic feet per second."
>
> "If our proposal is carried out the diversions will be about as follows:

DIVERSIONS ON THE AMERICAN SIDE	Cubic Feet Per Second
Niagara Falls	18,500
Chicago drainage canal	10,000
Total	28,500

DIVERSIONS ON THE CANADIAN SIDE	Cubic Feet Per Second
Niagara Falls and the Niagara Peninsula	36,000

"Permanent or complete diversions of such waters are wrong in principle and should hereafter be absolutely prohibited. The diversions by the Chicago Drainage Canal should be limited to the use of not more than 10,000 cubic feet per second."

"This would give an apparent advantage to Canadian interests, but, as the diversion is not of serious injury to the falls and does not materially affect the interests of navigation, it is more than counterbalanced by the complete diversion of 10,000 cubic feet by way of the Chicago Drainage Canal to the Mississippi River."

In response to a communication of the Secretary of State Elihu Root, the American Section of the International Commission made a report dated September 9, 1907, in which it quotes from its report of March 19, 1906, as follows:

"If the Falls are to be preserved it must be by mutual agreement between the two countries. As a step in that direction, we recommend that legislation be enacted which shall contain the following provisions, viz.:

"(a) The Secretary of War to be authorized to grant permits for the diversion of 28,500 cubic feet per second, and no more, from the waters naturally tributary to Niagara Falls, distributed as follows:

	Cubic Feet
Niagara Falls Hydraulic Power and Manufacturing Company	9,500
Niagara Falls Power Company	8,600
Erie Canal or its tenants (in addition to lock service)	400
Chicago Drainage Canal	10,000

"(b) All other diversion of water which is naturally tributary to Niagara Falls to be prohibited, except such as may be required for domestic use or for the service of locks in navigation canals.

"(c) Suitable penalties for violation of the law to be prescribed.

"(d) The foregoing prohibition to remain in force two years, and then to become the permanent law of the land, if, in the meantime, the Canadian Government shall have enacted legislation prohibiting the diversion of water which is naturally tributary to Niagara Falls in excess of 36,000 cubic feet per second, not including the amounts required for domestic use or for the service of locks in navigation canals. It is assumed, however, that an understanding upon the subject would be reached by treaty.

"The object of such legislation would be to put a stop to further depletion of the Falls, and at the same time inflict the least possible injury upon the important interests now dependent upon this water power. The amount to be diverted on the Canadian side has been fixed with a view to allowing the companies on that side the amounts for which they now have works under construction, which are:

	Cubic Feet
Canadian Niagara Power Company	9,500
Ontario Power Company	12,000
Electric Development Company	11,200
Niagara Falls Park Ry. Co	1,500
Welland Canal or its tenants (in addition to lock service)	1,800

"One of the effects of such legislation would be to give Canada the advantage of diverting 7,500 cubic feet per second more than is diverted in the United States. The advantage is more apparent than real, since the power generated on the Canadian side will to a large extent be transmitted to and used in the United States. In the negotiation of a treaty, however, the point should be considered."

The International Waterways Commission in its joint report of May 3, 1906, addressed to the Minister of Public Works of Canada and the Secretary of War of the United States, said in paragraphs 2 and 3:

(2) "While the commission are not fully agreed as to the effect of diversions of water from Niagara Falls, all are of the opinion that more than 36,000 cubic feet per second on the Canadian side of the Niagara River or on the Niagara peninsula, and 18,500 cubic feet per second on the American side of the Niagara River including diversions for power purposes on the Erie Canal, cannot be diverted without injury to Niagara Falls as a whole.

(3) "The Commission, therefore, recommend that such diversions, exclusive of water required for domestic use or the service of locks in navigation canals, be limited on the Canadian side to 36,000 cubic feet per second, and on the United States side to 18,500 cubic feet per second (and in addition thereto, a diversion for sanitary purposes not to exceed 10,000 cubic feet per second, be authorized for the Chicago Drainage Canal), and that a treaty or legislation be had limiting these diversions to the quantities mentioned."

When negotiations were in progress for the Treaty, the International Waterways Commission made an additional joint report, dated January 4, 1907, confined specifically to the diversion in the Chicago Drainage Canal. Certain significant paragraphs are as follows:

(m) "The diversion of large bodies of water from Lake Michigan for supplying the drainage canal has not been authorized by Congress, but there appears to be a tacit general agreement that no objection will be made to the diversion of 10,000 cubic feet per second, as originally planned."

(r) "The diversion of 10,000 cubic feet of water per second at Chicago will render practicable a waterway to the Mississippi River, 14 feet deep. Any greater depth must be obtained by the abstraction of more water from Lake Michigan and at the expense of the navigation interests of the Great Lakes and of the Saint Lawrence valley.

(s) "The effect upon Niagara Falls of diverting water at Chicago is of secondary importance when considering the health of a great city and the navigation interests of the Great Lakes and of the Saint Lawrence valley, but it is proper to note that the volume of the Falls will be diminished by the full amount diverted at Chicago.

Boundary Waters Treaty

The International Waterways Commission was organized by joint action of the Governments of Canada and the United States for the purpose of studying all questions relating to boundary waters and making investigations as to and reporting upon the terms of a Treaty in contemplation between the United States and Great Britain as to Canadian boundary waters. The Treaty was made on January 11, 1909, and was based upon the reports and recommendations of the International Waterways Commission. Not only the facts concerning the making of the Treaty, but a reading of the Treaty itself demonstrates this. We refer to some of the provisions of the Treaty.

Article II of the Treaty provides:

"Each of the high contracting parties reserves to itself or to the several State Governments on the one side, and the Dominion or Provincial Governments on the other, as the case may be, subject to any treaty provisions now existing with respect thereto, the exclusive jurisdiction and control over the use and diversion, whether temporary or permanent, of all waters on its own side of the line which in their natural channels would flow across the boundary or into boundary waters; but it is agreed that any interference with or diversion from their natural channel of such waters on either side of the boundary, resulting in any injury on the other side of the boundary shall give rise to the same rights and entitle the injured parties to the same legal remedies as if such injury took place in the country where such diversion or interference occurs; **but this provision shall not apply to cases already existing or to cases expressly covered by special agreement between the parties hereto."**

Article III of the Treaty provides:

"It is agreed that, in addition to the uses, obstructions, and diversions heretofore permitted or hereafter provided for by special agreement between the parties hereto, no further or other uses or obstructions or diversions, whether temporary or permanent, of boundary waters on either side of the line, affecting the natural level or flow of the boundary waters on the other side of the line, shall be made except by authority of the United States or the Dominion of Canada within their respective jurisdictions and with the approval, as hereinafter provided, of a joint commission, to be known as the International Joint Commission. * * * **Nor are such provisions intended to interfere with the ordinary use of such waters for domestic and sanitary purposes."**

Again, in Article VIII of the treaty, it is provided:

"The following order of precedence shall be observed among the various uses enumerated hereinafter for these waters, and no use shall be permitted which tends materially to conflict with or restrain any other use which is given preference over it in this order of precedence:

1. **Uses for domestic and sanitary purposes;**
2. Uses for navigation, including the service of canals for the purposes of navigation;
3. Uses for power and for irrigation purposes."

The treaty expressly carries out the intention of its framers as shown from the documents above mentioned. The Chicago diversion was recognized and protected by the express provisions of the treaty to the full, maximum extent of the diversion claimed. It was provided, as stated, **that existing diversions should not be disturbed,** and that **the consent of the Canadian Government and the International Joint Commission, organized by the treaty should not be required for diversions for domestic and sanitary purposes,** and **the Chicago diversion was recognized as a diversion for a sanitary purpose.** These conclusions are inevitable. The Canadian section of the International Waterways Commission expressly recommended a diversion to the extent of 10,000 second feet.

Congress by its acts has shown an intention to itself deal with this diversion.

In this connection we wish to call attention, in chronological order, to various acts and joint resolutions of Congress passed since the drainage channel was constructed:

Act of Congress of March 3, 1899, provided (Laws of United States relating to Improvement of Rivers and Harbors, Vol. 2, 879):

"Illinois River and Des Plaines River, Illinois: The Secretary of War is directed to appoint a board of three engineers, which board shall make a survey and estimates of cost for the improvement of the Upper Illinois River and Lower Des Plaines River, in Illinois, with a view to the extension of navigation from the Illinois River to Lake Michigan at or near Chicago; said board of engineers shall report the estimates of cost for a channel seven feet deep, and also for a channel eight feet deep, throughout said proposed route; said survey and estimates of cost shall be made in pursuance of and according to the recommendations in report of January twenty-seventh, eighteen hundred and ninety-seven."

The report of January 27, 1897, referred to in said Act of Congress, among other things, provides (Rec. Vol. 4, 2204):

"The sanitary district of Chicago has nearly completed a canal for drainage purposes from Chicago River at Robey street to near Lockport from 18 to 22 feet in depth below the proposed water surface, and varying

in width from 160 feet in rock to more than 200 feet in earth, a length of 28 miles, which may be made available as part of any enlarged water-way over the route in question, and is of much greater dimensions than required by any commercial canal adapted for the conditions and requirements of present or prospective traffic by water between Lake Michigan and the region along the water courses of the Mississippi Valley. To comply with the law of the State of Illinois under which this drainage canal is constructed — **it has been constructed of a capacity to discharge 600,000 cubic feet per minute through the section excavated in rock and 300,000 cubic feet per minute throughout the earth section — the law requires a discharge of 20,000 cubic feet per minute for each 100,000 inhabitants of the drainage district which at present requires more than 300,000 cubic feet and in a few years will require the full 600,000 cubic feet discharge through the canal. The taking of water from Lake Michigan, however, for drainage purposes (or rather for dilution of sewage) has not yet been authorized by Congress."**

The Act of March 3, 1899, also contains the Sections 9, 10 and 12 under which the United States is seeking an injunction in this case. The said report of January 27, 1897, was specifically referred to, and the facts stated in it and its recommendations relating to the use of the main channel of the Sanitary District as part of the waterway to the Mississippi River and the Gulf of Mexico, were known to and considered by Congress. The use of the Sanitary District works for the withdrawal of water from Lake Michigan to the maximum amount of 600,000 cubic feet per minute or 10,000 cubic feet per second, is specifically mentioned in the report. Congress does not in that Act prohibit nor does it condemn the diversion, but recognizes it and at least treats it as a subject for Congressional regulation, and not one for regulation by an executive officer.

Act of Congress of June 6, 1900, further carrying out the purpose of said Act of March 3, 1899, provided (Laws of United States relating to improvement of Rivers and Harbors, Vol. 2, 914):

"That the board of three engineers, appointed by the Secretary of War, in pursuance of a paragraph in the river and harbor Act approved March third, eighteen hundred and ninety-nine, to make a survey and estimates of cost of the improvement of the Upper Illinois River and the Lower Des Plaines River in Illinois, with a view to the extension of navigation from the Illinois River to Lake Michigan at or near the City of Chicago, is hereby authorized to report the estimates of cost for a channel ten feet deep, and for a channel twelve feet deep, and for a channel fourteen feet deep through said proposed route, and that the said estimates cover and include a proper **connection at Lockport with the sanitary and ship canal which has been constructed by the sanitary district of Chicago.** The said board of engineers is also further authorized to make a survey and estimates of cost for the improvement of the Lower Illinois River from the end of said proposed route to the mouth of said river, for channels ten, twelve, and fourteen feet

deep, respectively, and to report the estimates of cost thereof: **And provided further,** That surveys and estimates of cost shall be made in pursuance of the provisions contained in the Act aforesaid."

Act of Congress of June 13, 1902, provided (Laws of United States relating to Improvement of Rivers and Harbors, Vol. 2, 995):

"The sum of two hundred thousand dollars, or so much thereof as may be necessary, is hereby appropriated for making such surveys, examinations, and investigations as may be required to determine the feasibility of, and to prepare and report plans and estimates of cost of, a navigable waterway fourteen feet in depth **from Lockport,** Illinois, by way of the Des Plaines and Illinois rivers, to the mouth of said Illinois River, and from the mouth of the Illinois River, by way of the Mississippi River, to Saint Louis, Missouri."

Section 4 of the same act provided for the establishment of the International Water-ways Commission, to make among other things a study and report to Congress upon the regulation of diversions of water. The members of the International Water-ways Commission appointed under said Act, were to act in conjunction and co-operation with members of said Commission to be appointed by the Government of Canada. Said section is in part as follows (Laws of United States relating to Improvement of Rivers and Harbors, Vol. 2, 1007):

"That the President of the United States is hereby requested to invite the Government of Great Britain to join in the formation of an international commission, to be composed of three members from the United States and three who shall represent the interests of the Dominion of Canada, whose duty it shall be **to investigate and report upon the conditions and uses of the waters adjacent to the boundary lines between the United States and Canada, including all of the waters of the lakes and rivers** whose natural outlet is by the River Saint Lawrence to the Atlantic Ocean; **also upon the maintenance and regulation of suitable levels; and also upon the effect upon the shores of these waters and the structures thereon,** and **upon the interests of navigation, by reason of the diversion of these waters from or change in their natural flow;** and further, to report **upon the necessary measures to regulate such diversion,** and to make such recommendations for improvements and **regulations as shall best subserve the interests of navigation in said waters.** The said Commissioners shall report upon the advisability of locating a dam at the outlet of Lake Erie, with a view to determining whether such dam will benefit navigation, and if such structure is deemed advisable, shall make recommendations to their respective Governments looking to an agreement or treaty which shall provide for the construction of the same, and they shall make an estimate of the probable cost thereof."

No other inference can be drawn from the use of the words

"to report upon the necessary measures to regulate such diversion, and to make such recommendation for improvements and **regulations as shall best subserve the interests of navigation in said waters"**

than that they referred to the Chicago diversion for sanitary purposes alone, and that said diversion should continue as the paramount use, the use for navigation being subservient, but affected as little as possible by said diversion after proper regulating works were constructed.

Resolution of April 21, 1904, specifically with reference to the crests of the dams at Kampsville and Lagrange is as follows (Laws of United States relating to Improvement of Rivers and Harbors, Vol. 2, 1049):

> **"Resolved by the Senate and House of Representatives of the United States of America in Congress assembled,** That the Secretary of War is hereby authorized, in his discretion, with the concurrence of the Chief of Engineers, to permit the Sanitary District of Chicago, at the expense of said corporation, to lower the height of the Government dams in the Illinois River at Kampsville and Lagrange, Illinois, in accordance with such plans as he may prescribe and subject to such stipulations and conditions as, in his judgment, may be necessary to protect the interests of the United States."

Act of Congress of June 29, 1906 provided (Laws of United States relating to Improvement of Rivers and Harbors, Vol. 2, 1192):

> "That the diversion of water from Niagara River or its tributaries, in the State of New York, is hereby prohibited, except with the consent of the Secretary of War as hereinafter authorized in section two of this Act: **Provided, That this prohibition shall not be interpreted as forbidding the diversion of the waters of the Great Lakes or of Niagara River for sanitary or domestic purposes, or for navigation, the amount of which may be fixed from time to time by the Congress of the United States or by the Secretary of War of the United States under its direction."**

The foregoing Act related to the preservation of Niagara Falls, which was being injured primarily by the use of the waters of the Niagara River for the development of water power. If the Rivers and Harbors Act of March 3, 1899, under which the Government is seeking an injunction here, authorized the Secretary of War to regulate diversions of water, there would have been no occasion for the passage of this Act, for the Secretary of War could have regulated or limited diversions of water from the Niagara River for water power purposes under the '99 Act as well as under the Act just quoted. Congress carefully by the proviso mentioned, indicates its intention that, under no circumstances, not even for the preservation of the scenic beauty of the Falls, shall the diversion at Chicago for domestic and sanitary purposes be affected, except as Congress may thereafter fix the amount. The words

> "or by the Secretary of War of the United States under its direction,"

mean that the Secretary of War may be **thereafter** directed how to fix that diversion. These words absolutely negative the idea that the Secretary of War was **then** authorized under any Act of Congress to

fix the amount of the diversion. **No Act has been passed since authorizing the Secretary of War to limit or in any way affect the diversion for sanitary purposes.**

Act of Congress of March 2, 1907, provided (Laws of United States relating to Improvement of Rivers and Harbors, Vol. 2, 1261):

> "The Secretary of War may appoint a board of five members, to be composed of three members of the Mississippi River Commission, one of whom shall be the president of such Commission, and two engineer officers of the United States Army, to examine the Mississippi River below Saint Louis and report to Congress, at the earliest date by which a thorough examination can be made, upon the practicability and desirability of constructing and maintaining a navigable channel fourteen feet deep and of suitable width from Saint Louis to the mouth of the river, either by the improvement of said river or by a canal or canals for part of said route. In its report the board shall cover the probable cost of such improvement, the probable cost of maintenance, and the present and prospective commerce of said waterway, both local and general, upstream as well as downstream, **and the said board may consider in connection with the examination herein provided for, the survey of a proposed waterway from Chicago to Saint Louis, heretofore reported."**

Act of Congress of March 3, 1909 provided (Laws of United States relating to Improvement of Rivers and Harbors, Vol. 2, 1335):

> "The President of the United States is respectfully requested to open negotiations with the Government of Great Britain for the purpose of effectually providing by suitable treaty with said Government, **for maintaining ample water levels for the uses of navigation in the Great Lakes and the waters connected therewith,** by the construction of such controlling and remedial works in the connecting rivers and channels of such lakes as may be agreed upon by the said governments under the provisions of said treaty."

Joint resolution of Congress relating to the said Act of June 29, 1906, for the preservation of Niagara Falls, was passed March 3, 1909, and is as follows (Laws of United States relating to Improvement of Rivers and Harbors, Vol. 2, 1354):

> "Whereas the provisions of the Act entitled 'An Act for the control and regulation of the waters of Niagara River, for the preservation of Niagara Falls, and for other purposes,' approved June twenty-ninth, nineteen hundred and six, will expire by limitation on June twenty-ninth, nineteen hundred and nine; and
>
> "Whereas a date for the termination of the operation of said Act was provided therein, but with a view to the more permanent settlement of the questions involved by a treaty with Great Britain and by further legislation appropriate to the situation, and such treaty not having been negotiated, it is desirable that the provisions of said Act should be continued until such permanent settlement can be made; Therefore be it **Resolved by the Senate and House of Representatives of the United States of America in Congress assembled,** That the provisions of the aforesaid Act be, and they are hereby,

extended for two years from June twenty-ninth, nineteen hundred and nine, being the date of the expiration of the operation of said Act, save in so far as any portion thereof may be found inapplicable or already complied with."

Act of Congress of June 25, 1910 provided (Laws of United States relating to Improvement of Rivers and Harbors, Vol. 2, 1420):

"For the construction of a waterway from Lockport, Illinois, by way of the Des Plaines and Illinois rivers to the mouth of said Illinois River, one million dollars. The Secretary of War shall appoint a board of five members, to be composed of four engineer officers of the army and one civil engineer taken from civil life. The president of the board of five members authorized under Act of March second, nineteen hundred and seven, to examine the Mississippi River below Saint Louis and report to Congress on the project of a fourteen-foot channel, shall be a member of and president of the board herein provided for. Said board shall report upon the feasibility of such waterway, and the most advisable depth and dimensions therefor, in case the same is recommended; **also upon such measures as may be required to properly preserve the levels of the Great Lakes and to compensate, so far as practicable, for the diminished level in said lakes and the connecting waters thereof by reason of any diversion of water from Lake Michigan for the maintenance of the proposed waterway herein described, or diversion for any other purpose**; and further, also, upon the influence on volume and height of waters in the Mississippi River below Cairo."

Joint resolution of Congress passed August 22, 1911 provided (Laws of United States relating to Improvement of Rivers and Harbors, Vol. 2, 1505):

"**Resolved by the Senate and House of Representatives of the United States of America in Congress assembled,** That the provisions of an Act entitled 'An Act for the control of the waters of Niagara River, for the preservation of Niagara Falls, and for other purposes,' be and they are hereby, extended and re-enacted from June twenty-ninth, nineteen hundred and eleven, being the date of the expiration of the operation of said Act, to March first, nineteen hundred and twelve."

Act of Congress of August 24, 1912 provided (Laws of United States relating to Improvement of Rivers and Harbors, Vol. 2, 1568):

"SURVEY OF NORTHERN AND NORTHWESTERN LAKES: For survey of northern and northwestern lakes, including all necessary expenses for preparing, correcting, extending, printing and issuing charts and bulletins, **and of investigating lake levels, with a view to their regulation,** $125,000."

Joint resolution of Congress passed June 30, 1917 (Report on Diversion of Water from Great Lakes and Niagara River, Page 13), is as follows:

"**Resolved by the Senate and House of Representatives of the United States of America in Congress assembled,** That public resolution numbered forty-five of the Sixty-fourth Congress, approved January 19, 1917, entitled 'Joint resolution authorizing the Secretary of War to issue permits for

additional diversion of water from the Niagara River,' is continued in full force and effect, and under the same conditions, restrictions, and limitations, until July 1, 1918: **Provided,** That the Secretary of War is hereby authorized and directed to make a comprehensive and thorough investigation, including all necessary surveys and maps, **of the entire subject of water diversion from the Great Lakes and the Niagara River, including navigation, sanitary and power purposes,** and the preservation of the scenic beauty of Niagara Falls and the rapids of Niagara River, and to report to Congress thereon at the earliest practicable date. To carry out the provisions of this proviso there is hereby appropriated, out of any money in the Treasury not otherwise appropriated, the sum of $25,000."

It is clear that Congress, by its own acts and by the Treaty of 1909 with reference to Canadian boundary waters, has considered the diversion, as the International Waterways Commission did, a part of and necessary to the vital, physical and commercial development of that region of the United States surrounding the Great Lakes. One of the conditions of every permit issued to the Sanitary District with reference to the opening of its channel and the improvement of the Chicago River was, that the Secretary of War intended to place the matter before Congress, and that congressional action should nullify the permit. It appears in the record that the Secretary of War did make those reports; that Congress has done nothing in the way of condemning the operation of the Sanitary District works, but, on the contrary, has sought to utilize such works for navigation purposes and to preserve the levels of the lakes with the diversion existing, if such diversion has any effect upon such levels. It must be borne in mind, in this connection, that the effect of 10,000 cubic seconds feet diversion at Chicago does not exceed the effect of diversions from the Niagara River and Lake Erie made by water power interests and others. So, it is apparent that Congress has sought, and is seeking to provide facilities for navigation with the diversions existing. At least it has not yet considered it necessary to prohibit them. The non-action of Congress, under the circumstances, must necessarily be considered as an assent.

In

Corrigan Transit Co. v. Sanitary District, 137 Fed. 851, C. C. A., Seventh Circuit, 857.

the Court said:

"but if the matter is local, and concerns the public policy of a state, though it may incidentally affect interstate and foreign commerce, congressional inaction is a recognition that the subject is fitted for local regulation, and is an invitation that the state continue in the unimpeded exercise of its police powers, on the understanding, however, that Congress may thereafter intervene to the extent, at least, of destroying and forbidding whatever unnecessarily embarrasses commerce."

Navigation as to depths provided by Congress

All critical points of navigation have been improved by deepening since the drainage canal was opened, January 17th, 1900, to certain depths provided by acts of Congress. The depths provided by Congress have always been exceeded, and at no time has the water been of less depth than the project depth fixed under the acts of Congress. In the year 1911 the surface elevations of the lakes were lower than in any year since the opening of the drainage channel. It is only vessels carrying ore which can possibly be injured. The following is a table, marked Table I, which shows the movement of iron ore for the year 1921 as taken from Government reports—that is, the amount shipped from ports, and the amount received at different ports:

TABLE I.

TABLE SHOWING MOVEMENT OF IRON ORE DURING 1921.

HARBORS:		
Shipments—	Net Tons.	
Duluth, Minn	33,771,582	
Ashland, Minn	8,969,306	
Agate Bay, Minn	10,391,879	
Marquette, Mich	3,409,393	
Escanaba, Mich	351,285	
Total		56,893,445
Receipts—		
Milwaukee, Wis	144,500	
Calumet, Ill	7,275,558	
Indiana Harbor, Ind	1,426,983	
Rouge River, Mich	910,987	
Huron, Ohio	1,534,615	
Lorain, Ohio	4,508,600	
Cleveland, Ohio	8,957,165	
Fairport, Ohio	1,397,719	
Ashtabula, Ohio	12,351,940	
Conneaut, Ohio	6,708,534	
Erie, Pa	2,484,897	
Buffalo, N. Y	8,577,923	
Tonawanda, N. Y	602,695	
Miscellaneous	11,329	
Total		56,893,445

Table II, which follows, shows the project depths at critical points of navigation, and also in harbors shipping or receiving iron ore. This table also shows the depth of water at the points mentioned according to the mean of a sixty-two year period—from 1860 to 1921, and at the mean stage for the lowest month of the navigation season of the low water year of 1911.

TABLE II.

COMPARISON OF DEPTHS IN CERTAIN CHANNELS AND HARBORS AT SUNDRY ELEVATIONS OF THE WATERS OF LAKES MICHIGAN, HURON, ERIE AND SUPERIOR.

		Project depths of Acts of Congress. Standard Low Water.	Actual depths assuming water surfaces at mean for 62-year period 1860-1921.	Depths at 1921 Annual Mean.	Depths at 1911 Annual Mean. Lowest.	Depths at 1911 Navigation Season. Mean low.	Depths for lowest month for 1911 navigation season. Lowest monthly Mean.
CHANNELS:		Feet	Feet	Feet	Feet	Feet	Feet
St. Clair Flats Canal...		20.00	22.32	21.70	20.73	20.87	20.39
Livingston Channel.....		21.00	23.52	23.31	22.33	22.47	21.99
HARBORS:	LAKE						
Duluth, Minn.....	Superior	20.00	21.79	21.63	21.00	21.28	20.43
Ashland, Wis.....	Superior	20.00	21.79	21.63	21.00	21.28	20.43
Milwaukee, Wis.....	Michigan	19.00	21.63	20.60	20.10	20.23	19.87
Calumet, Ill.....	Michigan	21.00	23.63	22.60	22.10	22.23	21.87
Indiana Harbor, Ind....	Michigan	21.00	23.63	22.60	22.10	22.23	21.87
Rouge River, Mich.....	Detroit River	21.00	23.52	23.31	22.33	22.47	21.99
Toledo, Ohio.....	Erie	21.00	23.52	23.31	22.33	22.47	21.99
Huron, Ohio.....	Erie	19.00	21.52	21.31	20.33	20.47	19.99
Lorain, Ohio.....	Erie	20.00	22.52	22.31	21.33	21.47	20.99
Cleveland,Ohio.....	Erie	19.00	21.52	21.31	20.33	20.47	19.99
Fairport, Ohio.....	Erie	19.00	21.52	21.31	20.33	20.47	19.99
Ashtabula, Ohio.....	Erie	20.00	22.52	22.31	21.33	21.47	20.99
Conneaut, Ohio.....	Erie	20.00	22.52	22.31	21.33	21.47	20.99
Erie, Penna.....	Erie	20.00	22.52	22.31	21.33	21.47	20.99
Buffalo, N. Y.....	Erie	21.00	23.52	23.31	22.33	22.47	21.99
ELEVATIONS:							
Lake Michigan.....		578.50	581.13	580.10	579.60	579.73	579.37
Lake Erie.....		570.00	572.52	572.31	571.33	571.47	570.99
Lake Superior.....		600.50	602.29	602.13	601.50	601.78	600.95

APPENDIX "B"

THE WITHDRAWAL OF WATER FROM THE GREAT LAKES SYSTEM BY THE SANITARY DISTRICT OF CHICAGO

A Review by Francis C. Shenehon, Consulting Engineer

DECEMBER, 1921

(1) Introductory.—This review is intended as a discussion of the elements entering into the long-standing differences between the State of Illinois and the Federal Government concerning the withdrawal of water from Lake Michigan by The Sanitary District of Chicago. It purposes to state some facts and to examine the equities of each of these sovereign entities. These equities are not necessarily technical legal rights. They show different aspects when viewed from the navigational standpoint, the water power standpoint and the sanitary standpoint. The writer in his thirty years' study of Great Lakes problems has served as engineer for the United States, for Hydraulic Power Company at Niagara Falls and some years now for The Sanitary District of Chicago. Some advantage in clear apprehension comes from the many viewpoints occupied. On all hydraulic questions his attitude is the same now as when he testified as expert engineer for the United States. His unchanged earlier conclusions are incorporated in this review so far as these are pertinent. The review is not for use in a law court; it is understood that the evidence is closed. It is intended rather as an attempt to work out a constructive basis of understanding for the composing of differences. It is obvious that a discussion of this kind can carry no conviction unless its fairness is above reproach. An **ex parte** argument will defeat the very purpose of the review, and will therefore be of little service to the State of Illinois or to the Federal Government.

(2) The State of Illinois.—In speaking of the political subdivision comprised of the City of Chicago and the neighboring cities, towns and communities, incorporated and known as The Sanitary District of Chicago, it will serve several purposes to keep in mind the

more comprehensive parental entity of the State of Illinois. The Sanitary District is merely a child or agency of the State, doing certain things under enabling and mandatory laws of the state. The trustees can not diminish the volume of flow in the Drainage Canal without violating existing state laws. The real disagreement arises from a conflict of a state statute and federal authority. A larger conception of the parties in interest visualizes one as the State of Illinois—not the transient Trustees of the Sanitary District—and the other as the Federal Government—not the transient Secretaries of War. Perhaps the composition of differences will be on a higher plane when changing fallible individualities are eliminated from the equation and two permanent sovereign entities meet. The sanitary phase, which includes tolerable inoffensiveness in the Illinois River, touches the life and health of the people of the state for the full 300-mile length of the river. The navigational phase comprehends a canalized stream beginning at Lake Michigan in the northern part of the State and terminating toward the southern end of the State. The Drainage Canal is an essential link in this navigational route, for the construction of which the people of the State of Illinois have voted authority to issue bonds in the sum of Twenty Millions of Dollars to be expended with Federal approval and collaboration.

(3) Obstruction to Navigation.—The uncompensated diversion of 10,000 cubic feet of water at Chicago will actually lower the level substantially 5½ inches of Lakes Michigan, Huron, St. Clair, Erie and Ontario, and the appurtenant rivers, St. Marys, St. Clair, Detroit and the Upper St. Lawrence. This lower surface level will actually and practically constitute an obstruction to navigation by compelling the big lake freighters to carry a cargo less by 400 or 500 tons than these freighters would carry in the absence of the diversion of 10,000 cubic second feet. This should be understood as substantially accurate in measure of damage and a positive result of uncompensated diversion. It should be understood than this statement as to damage is simply a substantial reiteration of the writer's testimony as an engineering expert of the United States in the case of the United States vs. The Sanitary District. It can not be viewed as an admission by The Sanitary District itself to be used in any court.

(4) Water Power.—The diversion of 10,000 cubic feet per second of water at Chicago lessens the flow in the Niagara and St. Lawrence Rivers by the same amount, diminishing permanently the water power content of these streams. This volume of 10,000 cubic feet per second of water entering the Drainage Canal at Chicago adds permanently the same amount to the water power content of the Des Plaines, Illinois

and Mississippi Rivers, but the water power is less utilizable under present commercial conditions. It is conceivable that fifty or a hundred years hence this inherent potential energy or a substantial part of it may be commercially utilized. The potential energy in a cubic foot of water in Lake Michigan is just the same whether it is destined to reach tide water in the Gulf of St. Lawrence or in the Gulf of Mexico. In citing this axiom, it should be understood that the writer is fully cognizant of the water power difficulties in the Mississippi River below St. Louis, due to wide range in volume of flow, flat slopes and foundation conditions. The intent is to look fifty or a hundred years into the future—when water power may be fully utilized on the Niagara and St. Lawrence Rivers. The present situation on these rivers is one of waste and non-use.

(5) Regulation.—With the same positiveness with which the extent of navigational damage in the Great Lakes System is set down in paragraph 3, it must be stated that the lakes and rivers can be safely and certainly restored by compensating works, regulating works or by both. The engineering feasibility of safely and with certainty restoring lake and river levels is accepted by the Federal Government. The Sanitary District has the legal authority from the State of Illinois to finance works which will accomplish this restoration and is ready to place in the hands of the Federal Government funds representing its fair share of the reasonable cost of adequate works for this purpose. In this matter The Sanitary District does not impose regulating works of a particular type. It will collaborate in any scheme which the United States Engineers may suggest and will design for comparison and study various types of regulating works. Provided the plans of The Sanitary District, those already proposed or others still to be designed, are carried out, The Sanitary District guarantees satisfactory operation and full results.

(6) Restoration.—Assuming that adequate regulating works are in operation and that the levels of the lakes and rivers concerned are substantially restored from the foot of the locks in St. Mary's River to Montreal, then The Sanitary District may no longer be regarded as a national and international offender against the navigation of the Great Lakes over the channels mentioned. Under the scheme of regulation which the writer has demonstrated in his Report on the Regulation of the Niagara and St. Lawrence Rivers, Chicago becomes a benefactor to navigation in the lower St. Clair River, Lake St. Clair, the Detroit River and in Lake Erie—the most critical and densely navigated waters of the Great Lakes System—and in Lake Ontario and the St. Lawrence River above the Galops Rapids. If the United States Engineers feel

that the restoration of the channel depths from Buffalo to Sault Ste. Marie as proposed is in anyway incomplete, such modifications or amplifications of the restoration will be made. The Sanitary District will cooperate to the extent of designing other types of regulating works with a view to still greater navigational betterments in Lake Erie, with backwater reflections to Lakes Huron and Michigan and in St. Mary's River.

(7) Legal Aspect.—In this review the rigid legal aspect as between the State of Illinois and the Federal Government seems a minor consideration. The composing of differences appears to be more in the nature of the working out of a **modus vivendi** between a state and its colleagues. Illinois must assume a cooperative attitude and the Federal Government must forego any attitude of reprisal. A niggardly attitude on the part of Illinois is just as censurable as a disciplinary attitude on the part of the Federal Government. No poverty on the part of the people of The Sanitary District of Chicago exists which can prevent them from paying full measure for any benefit received at the expense of neighboring states—or from paying full measure to undo any damage that may accrue. And no desire exists in the central government to deal other than magnanimously and constructively in solving this problem. The legal aspect however, as between the State of Illinois and the Dominion of Canada must remain a rigid element in the solution of the problem. This will be discussed in succeeding paragraphs.

(8) Litigation.—The existing temporary permit of The Sanitary District is for 4,167 cubic feet of water per second and was issued in 1901. Since that time repeated applications for permission to divert larger amounts of water have failed. In 1907 an application for authority to construct a branch canal from Calumet to the Main canal at Sag, and to withdraw through it 4,000 cubic feet of water per second, was denied. Meanwhile the actual diversion of water considerably exceeded the permitted amount, the diversion keeping step with the Illinois statute requirements. In 1908 suit was begun by the Attorney General of the United States to enjoin the reversal of The Calumet River flow; and in 1913 a second suit was begun to enjoin any diversion from Lake Michigan in excess of the Federal permit. The two suits were consolidated and tried. Judge Landis deferred a decision through the war period, but rendered an oral opinion in June, 1920, sustaining the contentions of the United States. Attorneys for The Sanitary District were granted a hearing on a modification of the proposed injunction. This hearing has not yet been concluded. Obviously action by Congress will operate to terminate all litigation.

(9) Congressional Authority.—In refusing to issue a permit for any larger diversion by The Sanitary District both Secretary of War Taft and Secretary of War Stimson expressed the opinion that the wide-reaching effects of this diversion, national and international, removed the question of flow in excess of 4,167 cubic second feet beyond the jurisdiction of an officer of the Federal Government. The authority must come from Congress. In the case of the United States vs. The Sanitary District counsel for the United States urged that under existing law the courts could not give relief. Again it was a matter for Congress to determine. In this review it is assumed that the Congress of the United States will enact into law the limit of diversion, and impose certain conditions on the permitted diversion. These conditions will pertain to: The financing of compensating and regulating works to restore lake levels, a definite fixed program of construction of purification works, limitations of current in the Chicago River, supervision of diversion by the Secretary of War with a nominal charge for such supervision, limitations on variation of volume of flow, perhaps a limitation of the period of such diversion, with provision for recapture at the end of such period, or for a renewal for a second period, following the provisions of the Federal Water Power Act. The adjustment between a state and its colleagues may be worked out in a more magnanimous way by a law-making body than by a Federal Secretary with limited powers or by a court dependent upon precedent legal decisions crystallized in an earlier period, when sanitary needs or water power possibilities were trivial compared to the tremendous visible economic structure of water-borne commerce.

(10) Pollution—It must be clearly kept in mind that the sewage and wastes of a population of three million people are pouring day and night into the Drainage Canal and that in the very nature of things this prodigious volume of effluent cannot take any other route than through the divide. It is unthinkable that the disease-producing content of the sewer outflow should be diffused in Lake Michigan and mix with the drinking water of the people. It is unthinkable that it can stagnate in the Chicago River or in the Drainage Canal. No Trustee of the Sanitary District, no officer of the State of Illinois, no Secretary of War would have the temerity or conscience to close the gates at Lockport. Partial closing of the gates with lesser flow than the ratio of the Illinois Statute—1,000 cubic feet per second for each 300,000 of tributary population—is practicable at great expense with extensive sewage purification, and complete purification of the water supply. But even partial throttling of the present flow, averaging 9,000 cubic feet per second, must await the construction of substitute

sanitary devices. Without these extensive sanitary devices in use, restriction to the permitted flow of 4,167 cubic second feet would mean vast life hazards. The evil results include unwholesome conditions in the Chicago River, the Drainage Canal and the Illinois River—with accumulating putrid sludge beds, insufficient oxygen, long germ life and stench. Under exceptional rainfall and runoff in the watershed tributary to the Drainage Canal the contaminated waters may reach the water supply of Chicago and its neighboring cities. To what extent this effusion of sewage into the Lake may be mitigated by temporary emergency flow of 10,000 cubic feet per second is as yet an unsolved problem. Tests made by the Sanitary District engineers indicate an inertia in the canal flow, which makes a change of flow from 4,167 to 10,000 cubic feet per second a matter of many hours. With 6,800 cubic feet diversion per second under present population conditions the stench and the menace would be less. With the present diversion of 9,000 cubic feet per second, the lower canal and Illinois River conditions are such as to make that volume of flow an irreducible minimum. With the present volume of sewage and wastes the Illinois River needs **more** water rather than **less** water. In the end of course with more extensive purification, the volume of diversion water is dependent on population and the extent of this purification.

(11) No Diversion—Had the City of Chicago been located on the Lake Michigan shore with no possibility of recourse to sewage disposal through some southward-bound stream like the Illinois River, some other solution of its sewage disposal problem and its water supply problem would have been entirely practicable, just as the problems of Duluth, Milwaukee, Cleveland and Toronto are being solved. Widely separated water supply intakes and sewer outlets, with sewage treatment and complete water supply purification may yield excellent results. The City of Chicago must treat its water supply even with a diversion of 10,000 cubic feet per second in the Drainage Canal. The sanitary hazard of using untreated water from Lake Michigan is not worth while. The presence of organic matter, of storm-created roiling and of disease germs from vessels is probable enough to make water treatment desirable or imperative. And sewage treatment or purification must go on with increasing intensity and magnitude, to care for trade wastes and the ever-increasing population. It is not improbable that at some future time the fertilizer value of the sewage may warrant the complete separation of the solids. After a period of further use of its present vastly expensive sewage-dilution project a new generation may properly finance absolute sewage purification plants.

(12) Permitted Diversion—No claim can be substantiated that The Sanitary District of Chicago with its authorized flow of 4,167 is not better off than such cities as Cleveland, Milwaukee and Toronto, which have no diversion canals to carry their sewage effluent outside the lake from which their drinking water comes. The problems of these cities must be solved by rendering innocuous their sewage and wastes and purifying their water supply also. The Sanitary District of Chicago must eventually do both. It is a question of allowing the three million people of the Sanitary District to utilize their great 100-Million-Dollar investment. No suggestion on the part of the Federal Government has been made that the Drainage Canal as a sanitary device should be superannuated, to be written off the books as obsolescent. No need whatever of doing this for the good of navigation will exist when regulating works are installed. No need of this now exists for water power, because at Niagara only 635,570 horsepower out of two million or more available is in present actual use, and on the St. Lawrence River four million horsepower is running to waste. Navigational needs and water power needs are the only two external reasons for curtailing below 10,000 cubic second feet the volume of diversion in the Drainage Canal. Regulation in part at the expense of The Sanitary District of Chicago will care for navigation and make it better than before; ultimate economy in water power may become urgent in a half century; it is not urgent or existent in the Great Lakes System now. It would be an economic blunder to throttle the flow in the Drainage Canal for the purpose of water power conservation as long as the present conditions are perpetuated at Niagara Falls and on the St. Lawrence River.

(13) Waste at Niagara Falls—Taking the normal flow of the Niagara River as 200,000 cubic second feet (after diverting 10,000 cubic second feet at Chicago) and the full fall, Chippewa-Grass Island to Queenston-Lewiston, as 313 feet, and assuming an overall efficiency on the busses of 80 per cent, each cubic foot of water yields 28.5 horsepower. Taking the usable amount of water for power purposes as 70,000 cubic feet per second, the practicable energy releasable is roundly two million electrical horsepower. This leaves 4,625,000 water horsepower to vitalize the scenic grandeur of the river and falls. But of this practicably available power only 635,570 horsepower is now used. To secure this electric horsepower, 50,886 cubic feet per second are taken from the flow over the Cataracts, and an average of 12.5 horsepower per cubic foot of water used is secured. Assuming for the gross fall, Chippewa-Grass Island Pool to Maid of Mist Pool, 220 feet, and a practicable overall efficiency of 80 per cent, each cubic foot of water

used should yield 20 electrical horsepower. Out of the water used in this one major descent from above the Cataracts Rapids to the Gorge, a total of 432,531 electrical horsepower is wasted. It should be added that the now nearly completed development of the Hydro-electric Power Commission of Ontario will divert an additional 10,000 cubic feet per second, secure the full fall of 313 feet between Chippewa and Queenston and develop 294,000 electrical horsepower. (See Warren Report, 1921, p. 225.) No use whatever of the mill pond capacity of Lake Erie has yet been made to augment the water power volume at Niagara Falls. No use has been made of supplemental hydraulic and electric installations to take advantage of Niagara River flow in excess of a volume of 200,000 cubic feet per second.

(14) Canadian Navigation—So far as obstructions to navigation have existed since 1900 due to diversions of Lake Michigan water at Chicago, these are as real in Canadian channels and harbors as in the waters of the United States. However, as Canadian commerce is relatively small, the aggregate damage is not serious. Canada will not file other than perfunctory objections and she will not claim damage to navigation through the Sanitary District's diversion of 10,000 cubic feet per second. This is confidently stated for many reasons: Canada remembers appreciatively the Lock of 1855 at Sault Ste. Marie, built by the State of Michigan with Federal aid; she remembers that until 1895, or for forty years, the free use of the ship lock of the State of Michigan and those of the United States gave her ingress to Lake Superior and made useful the terminals at Port Arthur and Fort William; she remembers that for the past thirty years her vessels passed through the St. Marys, St. Clair and Detroit Rivers in channels dredged by the United States, which are six feet deeper than the earlier channels; Canada remembers this six feet added to vessel drafts rather than the few inches subtracted; Canada remembers also that she herself has not been entirely blameless in the matter of lowering of the levels of Lake Erie and the Niagara River through diversions for power purposes in the Welland Canal and at Niagara Falls; Canada bears in mind also that the Sanitary District has proposed to share in the undoing of any damage to navigable waters from Sault Ste. Marie to the head of Galops Rapids, while some of her colleagues in lake lowering are silent. The writer hastens to add that he believes that the United States remembers the magnificent flight of locks in the Welland Canal (and their enlargement) and the series of canals from the head of the Galops Rapids to the foot of the Lachine Rapids in the St. Lawrence River; and that Canada has doubtless spent as much money in her canalization projects as the United States has in all its Great Lakes

improvements. To square things the writer must add as a contribution of the United States toward navigation—the Panama Canal. Finally, Canada remembers the provisions of the Treaty of 1910.

(15) Uncompensated Waters—The scheme of restoration of water surface levels proposed by the Sanitary District includes all waters above the head of the Galops Rapids, or in the discretion of the United States and Canada, the foot of Rapide Plat, if that is selected as the best location for regulating works. The problem of the restoration of the Niagara River between Buffalo and the head of the Cataract Rapids appears to belong rightfully to the power companies of Niagara Falls as offenders-in-chief and beneficiaries of the restoration as well. The canalization of the St. Lawrence River for ocean drafts will create slackwater pools widely different in levels from the natural surfaces of the present river throughout the rapids section. The elevations of these various pools are arbitrary and do not involve the diversion at Chicago. At and below Montreal the lowering of the St. Lawrence River surface is believed to be too little to take cognizance of. By over-restoring or bettering lake and river levels in Lake Erie, the Detroit River, Lake St. Clair and the lower St. Clair River, and in Lake Ontario and the upper St. Lawrence River, the Sanitary District will have a credit toward a trivial lack of restoration in the lower St. Lawrence.

(16) Canadian Water Power—It has been shown at length that, when compensating and regulating works are constructed, in part at the expense of the Sanitary District, no real, tangible, substantial damage to navigation will remain. At Niagara Falls, two other elements of damage will emerge when the time arrives to use every foot of water fully and efficiently. These two elements are scenic grandeur and water power. If the Sanitary District diversion is charged to water power, no encroachment is then made on scenic grandeur. That is eliminated from consideration. It is a safe prediction that the vast water power content of the St. Lawrence River and the great additional water power content of the Ottawa River and various streams in the Province of Quebec, safeguard for all possible use the regional or transmissible needs for more than half a century. It was this vast, scarcely-touched richness in water resources that made the adjustments at Niagara Falls, as incorporated in the Treaty of 1910, an excellent bargain for the Dominion of Canada. It will be shown in a succeeding paragraph that by the terms of this treaty, Canada with its lesser population and its lesser water contribution to the volume of Niagara River flow, secured over 64 per cent of the water allotted to power

purposes and the United States less than 36 per cent. This strange, obviously disproportionate division is understandable only when the precedent facts are visible.

(17) Before the Treaty—The treaty between the United States and Great Britain proclaimed May 13, 1910, was based on certain recommendations made by the International Waterways Commission in its joint report of May 3, 1906, addressed to the Minister of Public Works of Canada and the Secretary of War of the United States. Paragraphs 2 and 3 of this joint report read:

> (2) "While the commission are not fully agreed as to the effect of diversions of water from Niagara Falls, all are of the opinion that more than 36,000 cubic feet per second on the Canadian side of the Niagara river or on the Niagara peninsula, and 18,500 cubic feet per second on the American side of the Niagara river, including diversions for power purposes on the Erie canal, cannot be diverted without injury to Niagara falls as a whole.
>
> (3) "The Commission, therefore, recommend that such diversions, exclusive of water required for domestic use or the service of locks in navigation canals, be limited on the Canadian side to 36,000 cubic feet per second, and on the United States side to 18,500 cubic feet per second (and in addition thereto, a diversion for sanitary purposes not to exceed 10,000 cubic feet per second, be authorized for the Chicago Drainage Canal), and that a treaty or legislation be had limiting these diversions to the quantities mentioned."

This joint report was accelerated by the then Secretary of State, Elihu Root, in a letter to the Secretary of War, William H. Taft, which was referred to the International Waterways Commission. The following is an extract from the letter:

> "The negotiation relating to a treaty on this subject has been suspended awaiting the further report of the commission, in accordance with the statements to which I have referred. There are many indications of active public interest in the subject, and a joint resolution having in view the preservation of the falls, pending in the House of Representatives, has been favourably reported by the Committee on Rivers and Harbors. The indications are that if an agreement can presently be reached between the two countries as to the action necessary to accomplish the purpose, any legislation to give the agreement effect on the part of the American authorities would receive favourable consideration at the present session of Congress and at the present session of the New York legislature.
>
> "It seems desirable, therefore, to press forward the negotiations for such an agreement without any avoidable delay. May I ask you to make such a report upon the subject as may furnish a basis upon which the State Department and the ambassador may take and proceed with the negotiations?"

The report of the International Commission followed.

(18) Before the Joint Report—The Dominion view of the diversions at Chicago and in and near the Niagara River is given in a report of the Canadian Section of the International Commission, dated April 25, 1906, to the Minister of Public Works. The following are extracts from the report:

"At Chicago, the Americans have built a drainage canal which, when in full operation, will use about 10,000 cubic feet of water per second."

"As the diversion from Lake Michigan to the Mississippi River is of a much more serious character than the temporary diversions from the Niagara River, it is felt that the amount of water to be taken on the American side of the Niagara River should be limited to 18,500 cubic feet per second."

"If our proposal is carried out the diversions will be about as follows:

DIVERSIONS ON THE AMERICAN SIDE

	CUBIC FEET PER SECOND
Niagara Falls	18,500
Chicago drainage canal	10,000
Total	28,500

DIVERSIONS ON THE CANADIAN SIDE

	CUBIC FEET PER SECOND
Niagara Falls and on the Niagara peninsula	36,000

"Permanent or complete diversions of such waters are wrong in principle and should hereafter be absolutely prohibited. The diversions by the Chicago drainage canal should be limited to the use of not more than 10,000 cubic feet per second."

"This would give an apparent advantage to Canadian interests, but as the diversion is not of serious injury to the falls and does not materially affect the interests of navigation, it is more than counterbalanced by the complete diversion of 10,000 cubic feet by way of the Chicago drainage canal to the Mississippi River."

The two reports referred to in paragraphs 17 and 18, including the letter of Secretary of State Elihu Root, dated February 13, 1906, are printed on pages 333 to 340, inclusive, of the volume entitled:

C A N A D A

Compiled Reports

of the

International Waterways Commission

1905-1913

Printed by Order of Parliament

Ottawa—1914

In response to a communication of the Secretary of State Elihu Root, the American Section of the International Commission made a report dated September 9, 1907, in which it quotes from its report of March 19, 1906, as follows:

"If the falls are to be preserved it must be by mutual agreement between the two countries. As a step in that direction, we recommend that legislation be enacted which shall contain the following provisions, viz:—

"(a) The Secretary of War to be authorized to grant permits for the diversion of 28,500 cubic feet per second, and no more, from the waters naturally tributary to Niagara Falls, distributed as follows:

	CUBIC FEET
Niagara Falls Hydraulic Power and Manufacturing Company	9,500
Niagara Falls Power Company	8,600
Erie Canal or its tenants (in addition to lock service)	400
Chicago Drainage Canal	10,000

"(b) All other diversion of water which is naturally tributary to Niagara Falls to be prohibited, except such as may be required for domestic use or for the service of locks in navigation canals.

"(c) Suitable penalties for violation of the law to be prescribed.

"(d) The foregoing prohibition to remain in force two years, and then to become the permanent law of the land, if, in the meantime, the Canadian Government shall have enacted legislation prohibiting the diversion of water which is naturally tributary to Niagara Falls in excess of 36,000 cubic feet per second, not including the amounts required for domestic use or for the service of locks in navigation canals. It is assumed, however, that an understanding upon the subject would be reached by treaty.

"The object of such legislation would be to put a stop to further depletion of the falls, and at the same time inflict the least possible injury upon the important interests now dependent upon this water power. The amount to be diverted on the Canadian side has been fixed with a view to allowing the companies on that side the amounts for which they now have works under construction, which are:

	CUBIC FEET
Canadian Niagara Power Company	9,500
Ontario Power Company	12,000
Electric Development Company	11,200
Niagara Falls Park Railway Company	1,500
Welland Canal or its tenants (in addition to lock service)	1,800

"One of the effects of such legislation would be to give Canada the advantage of diverting 7,500 cubic feet per second more than is diverted in the United States. The advantage is more apparent than real, since the power generated on the Canadian side will to a large extent be transmitted to and used in the United States. In the negotiation of a treaty, however, the point should be considered."

(See pages 610 to 611, Canadian Compilation).

It will be observed that both the Chicago diversion and that in the Welland Canal are specifically mentioned. It will appear later that neither is specifically mentioned in the Treaty, but each is authorized in general terms. The total quantities here recommended, **excluding the diversion at Chicago and in the Welland Canal,** are:

United States	18,500
Canada	34,200

(19) SUBSEQUENT REPORT—When negotiations were in progress for the Treaty, the International Waterways Commission made an additional joint report, dated January 4, 1907, confined specifically to the diversion in the Chicago Drainage Canal. Certain significant paragraphs are as follows:

(m) "The diversion of large bodies of water from Lake Michigan for supplying the drainage canal has not been authorized by Congress, but there appears to be a tacit general agreement that no objection will be made to the diversion of 10,000 cubic feet per second, as originally planned."

(r) "The diversion of 10,000 cubic feet of water per second at Chicago will render practicable a waterway to the Mississippi river, 14 feet deep. Any greater depth must be obtained by the abstraction of more water from Lake Michigan and at the expense of the navigation interests of the Great Lakes and of the St. Lawrence valley.

(s) "The effect upon Niagara Falls of diverting water at Chicago is of secondary importance when considering the health of a great city and the navigation interests of the Great Lakes and of the St. Lawrence valley, but it is proper to note that the volume of the falls will be diminished by the full amount diverted at Chicago."

RECOMMENDATIONS

(41) "The waters of Lake Michigan in the United States, the waters of Georgian Bay in Canada, and the waters of Lake Superior partly in the United States and partly in Canada, all form sources of supply of the Great Lakes system, finding their way by the St. Lawrence to the sea. All are interdependent and there can be no diversion from any of them without

injury to the whole system. By Article XXVI of the treaty of 1871 it is provided that 'navigation of the River St. Lawrence, ascending and descending from the forty-fifth parallel of north latitude, where it ceases to form the boundary between the two countries, from, to and into the sea, shall forever remain free and open for the purposes of commerce to the citizens of the United States, subject to any laws and regulations of Great Britain, or of the Dominion of Canada, not inconsistent with such privileges of free navigation.' It is desirable that in any treaty arrangement the waters of Lake Michigan, Georgian bay, and all other waters forming part of the Great Lakes system should be declared to be 'forever free and open for the purposes of commerce' to the citizens of the United States and the subjects of His Britannic Majesty, subject to any laws and regulations of either country not inconsistent with such privilege of free navigation.

(42) "The preservation of the levels of the Great Lakes is imperative. The interest of navigation in these waters is paramount, subject only to the right of use for domestic purposes, in which term is included necessary sanitary purposes. In our report of November 15, 1906, upon the application of the Minnesota Canal and Power Company to divert certain waters in Minnesota we recommend, among other things—'that any treaty which may be entered into should define the uses to which international waters may be put by either country without the necessity of adjustment in each instance, and would respectfully suggest that such uses should be declared to be (a) uses for necessary domestic and sanitary purposes; (b) service of locks for navigation purposes; (c) the right to navigate.' It is our opinion that so far as international action is concerned a treaty provision of that kind is all that is required in this case. We accordingly renew our recommendation of November 15, 1906, just quoted.

(43) "A careful consideration of all the circumstances leads us to the conclusion that the diversion of 10,000 cubic feet per second through the Chicago River will, with proper treatment of the sewage from areas now sparsely occupied, provide for all the population which will ever be tributary to that river, and that the amount named will therefore suffice for the sanitary purposes of the city for all time. Incidentally it will provide for the largest navigable waterway from Lake Michigan to the Mississippi River, which has been considered by Congress.

"We therefore recommend that the Government of the United States prohibit the diversion of more than 10,000 cubic feet per second for the Chicago Drainage Canal."

These paragraphs are quoted from pages 527 to 529 inclusive of the Canadian Compilation mentioned in Paragraph 18.

(20) The Treaty—The Boundary Waters Treaty between the United States and Great Britain was signed at Washington January 11, 1909, and ratifications were exchanged May 5, 1910. By Article V of this treaty diversions in cubic feet per second are allotted to each country "of the waters of the Niagara River above the Falls from the natural course and stream thereof" as follows:

United States in New York State	20,000
Canada in Province of Ontario	36,000

It is obvious that these round numbers of cubic feet were arrived at from the recommendation of the International Commission, as set down at the end of Paragraph 18 of this review, as follows:

COUNTRY—	RECOMMENDED	ADD TO ROUND OUT	TREATY
United States.....	18,500	1,500	20,000
Canada.....	34,200	1,800	36,000

It should be explained that the difference between these figures of the American Section of the Commission and those of the Canadian Section hinges on the estimated amount for power use in the Welland Canal, which was 1,800 cubic feet per second. The actual amount used in the Welland Canal for power purposes is 3,365 cubic feet per second. (See Colonel Warren's Report, 1921, page 198). It further appears from page 197 of this report that diversions through the Welland Canal for power purposes have substantially increased since the proclaiming of the treaty in 1910. The diversion at Chicago and the diversion for power purposes in the Welland Canal are not specifically mentioned. Each appears to be authorized by the general terms of the Treaty. The Chicago authorization is embraced in the following provisions of the Treaty:

> First.—Lake Michigan is not a boundary water—but a tributary of boundary waters. (See Preliminary Article and Article I).
>
> Second.—In Article II the diversion from water tributary to boundary waters is permitted subject to legal remedies for injury to the other party, "but this provision shall not apply to cases already existing." The Chicago Drainage Canal diversion was a case "already existing" in fact.
>
> Third.—Article III refers to boundary waters and does not include Lake Michigan. The Welland Canal diversion for power purposes is authorized as "heretofore permitted."

(21) FRAMING THE TREATY—No doubt should exist as to the Treaty authorization of a 10,000 cubic feet per second diversion by the Sanitary District. With the concurrence of the American Section and of the Canadian Section separately reported, giving detailed illumination on the reasons for the various amounts recommended, and with the joint report of the International Waterways Commission before them, is it reasonable that the Secretary of State of the United States Elihu Root and the Ambassador of Great Britain James Bryce, knowingly neglected to safeguard the public interests of the people of the State of Illinois, while carefully safeguarding the private corporations of the State of New York and of the Province of Ontario? If on the other

hand the framers of the Treaty intended to protect the residents of The Sanitary District of Chicago, but failed to give this intent legal expression, a new light is thrown on the mentalities of Elihu Root and James Bryce.

(22) Protection of Investments — The first paragraph of Article V reads as follows:

> "The High Contracting Parties agree that it is expedient to limit the diversion of waters from the Niagara River so that the level of Lake Erie and the flow of the stream shall not be appreciably affected. It is the desire of both Parties to accomplish this object with the least possible injury to investments which have already been made in the construction of power plants on the United States side of the river under grants of authority from the State of New York, and on the Canadian side of the river under licenses authorized by the Dominion of Canada and the Province of Ontario."

The volumes of flow made permissible under the treaty considerably exceeded the amounts necessary to protect the then existing investments. Up to date, August, 1919, of the Warren Report, neither the merged American Power Companies nor the Canadian Power Companies had been able to use the water allotted. It is unthinkable that the investments of these private corporations were cared for, while the much greater financial investment of the people of Illinois, made for the preservation of public health, was not safeguarded.

(23) Canadian Acquiescence—It appears in the various citations and conclusions reached in paragraphs 17 to 22 of this review that the Dominion through the Canadian Section of the International Waterways Commission intended that a diversion not to exceed 10,000 cubic feet per second should be authorized in the Chicago Drainage Canal, and it appears also that this intent was conveyed to the Ambassador of Great Britain, and that this intent was written into the Treaty, and was acquiesced in and effectuated by the ratification of Great Britain. The acquiescence of Canada in the Chicago diversion, through the Canadian Section of the International Waterways Commission and by ratification of the Treaty is so complete and final that perhaps any further proof of intent is unnecessary. It may be argued, however, that the prohibition of any diversion in excess of 10,000 cubic feet per second was not intended as acquiescing in the full diversion of this maximum. It is illuminating therefore to note the wording of a report of the Canadian Section of the International Commission dated March 9, 1908, as indicative of its understanding that this volume of diversion was an accepted accomplished fact. See Canadian Compilation, page 627:

"Vast interests are involved. The amount by which the mean level will be lowered by the discharge of 10,000 cubic feet **now authorized** through the Chicago Canal, is estimated at about six inches in Lakes Huron and Michigan, about five inches in Lake Erie and four inches in Lake Ontario. Any further diversion would mean the necessary expenditure of a very large amount of money to restore depths in harbours and to maintain a uniform draft of fourteen feet in our canal system."

The basis of Canadian opposition to granting the Sanitary District a diversion of 10,000 cubic feet per second disappears in the light of this action of its own International Waterways Commission on which the Treaty was predicated, and in the light of the authorization of the Treaty itself.

(24) The Outlaw—Notwithstanding the equitable conclusions reached back in 1906 by the joint report of the International Waterways Commissioners, the Sanitary District has long been considered an outlaw in effect in the minds of certain officers of the United States. For this agency of the State of Illinois to go on diverting 8,000 or 9,000 cubic feet per second from Lake Michigan—when authorized to divert only 4,167—in its **prima facie** aspect appears to be defiance of the War Department of the United States. Viewed more profoundly, however, the Sanitary District has questioned the finality of the limitation of its diversion to 4,167 cubic feet per second, and regards the decision of the Secretary of War not as a prohibition but as a statement of lack of jurisdiction to permit more. While the matter is before the courts, the outlawry is not operative. Let it be frankly set down, however, that some earlier manners, methods and defiances of certain Trustees of the Sanitary District created about this municipal organization an atmosphere of unfriendliness, which makes difficult the discernment of its equitable deserts now. In an adjustment of the diversion it should not be necessary to penalize and put on probation the three million people of the second largest city of the country and the neighboring communities, for the sins of some of their Trustees years ago. It should be kept clearly in mind that the diversion over or through the divide at Chicago to the Desplaines River represents an evolution and a growth from a beginning a hundred years ago. In 1822 the Congress of the United States recognized the value of a navigable canal from Lake Michigan to the Illinois River; and a few years later (1827) authorized the construction of this canal and aided the project with a land grant, just as about 1850 the State of Michigan was aided at Sault Ste. Marie. This little canal was a legitimate child of the Federal government. The writer does not construe this early venture as a reason and authorization for all of the present diversion, but it pointed

the way. Successive and increasing uses of the breached divide, by pumping and by gravity, represent growth from a practice legitimately established.

(25) Other Outlaws—In passing judgment upon the Sanitary District it is desirable in the interest of fair play to visualize the conditions in the Great Lakes System back in 1889 when The Sanitary District Act was passed by the Illinois Legislature. It was largely the custom and practice at that time to divert water from a lake or river with no other authority than the state or the province. The United States had not fully emerged as the sole custodian on the American side, nor had the Dominion emerged as the sole custodian on the Canadian side and the international aspect was obscure. Prior to 1907 diversions of 11,000 cubic feet per second of water from the Niagara River above Niagara Falls were in effect on the American side; and on the Canadian side a similar diversion was made by the Ontario Company. The diversion of these aggregate volumes of river water caused measurable decreases in vessel channel depths in navigable waters of the United States and Canada. The diversions on the American side were made without Federal authorization under charter rights granted by the State of New York, just as the Sanitary District secured its charter rights from the State of Illinois. The diversion on the Canadian side was under rights from the Province of Ontario, not from the Dominion Government. None of these diversions was made under international sanction. The diversions simply conformed to the custom and practice of that time.

(26) Warren Report—A valuable report on a comprehensive investigation, made under the direction of Colonel J. G. Warren of the Corps of Engineers, U. S. Army, has been issued as of date 1921. That portion of the report prepared by Colonel Warren personally bears date of August 30, 1919. After discussing the Chicago situation, the following recommendations are made: (See page 101).

(1) That Federal control of the diversion at Chicago and in the vicinity be established by such measures as are necessary, provided the United States courts do not uphold the present apparent right of the Federal Government to regulate the diversions there.

(2) That The Sanitary District of Chicago be permitted to divert from Lake Michigan and its tributaries a total quantity of water not exceeding at any time a flow of 10,000 cubic feet per second.

(3) That the Secretary of War shall supervise the diversions as he deems best.

(4) That the expense of supervision shall be paid for promptly at stated intervals by The Sanitary District of Chicago.

(5) That no dangerous condition shall be created in navigable waters.

(6) That The Sanitary District agree to be responsible for any damage claims arising because of the diversion.

(7) That it shall pay its share as determined by the Secretary of War of the cost of such compensating works as the Federal Government considers necessary because of diversions of water from the Great Lakes system.

(8) That it agree not to request or make any diversion in excess of that herein stated.

(9) That it shall pay to the United States for water used for power purposes at a rate per cubic foot to be based upon the relative value of the power as developed and that which could have been developed by its use at Niagara Falls, N. Y., and along the St. Lawrence River.

(10) That it do all in its power to secure any State authority needed to enable it to undertake the establishment of provisions for sewage disposal other than by dilution.

(11) That when so enabled, it provide as rapidly as necessary such sewage disposal facilities as are needed to care for the growth of the district.

It must be kept vividly in mind that these conditions are intended to be imposed—not on a powerful private corporation—but on a municipality, and that this municipality is using the water primarily for sanitary purposes—the first preferential use under the Treaty.

(27) Conditions—The Sanitary District will not protest any conditions of use which are just and serve some desirable purpose; but it may properly object to conditions more severe than those imposed on private corporations diverting water for power purposes, or conditions which are punitive in character. A state and a municipality under the Federal Water Power Act are given preferential, rather than subordinate, treatment.

(28) Preferential Uses—In Article VIII of the Treaty the High Contracting Parties have agreed on priorities of use:

"The following order of precedence shall be observed among the various uses enumerated hereinafter for these waters, and no use shall be permitted which tends materially to conflict with or restrain any other use which is given preference over it in this order of precedence:

First.—Uses for domestic and sanitary purposes.

Second.—Uses for navigation, including the service of canals for the purpose of navigation.

Third.—Uses for power and for irrigation purposes.

The foregoing provisions shall not apply to or disturb any existing uses of boundary waters on either side of the boundary."

While the order of priorities is established for the guidance of the International Joint Commission in the determination of new cases arising after the Treaty became effective, it is an expression of vital principles. The water diverted from Lake Michigan serves all three of the purposes set down in the Treaty:

(1) It protects the water supply and is the vehicle of the disposal of sewage.

(2) It makes practicable and economical a 14-foot navigable waterway leading toward the Gulf of Mexico.

(3) It is utilizable for water power.

It should be added in order to keep this constantly in mind that the only loss to the Great Lakes System is in the water power content of rivers so rich in water power that up to the present time only about ten per cent of the energy available is in use.

(29) Board of Engineers—The Warren Report was reviewed by the Board of Engineers for Rivers and Harbors; and this Board made its recommendations August 24, 1920, nearly a year after the submission of the report reviewed. The Board report is constructive in many respects. The Board dissents from Colonel Warren in two points: The Board recommends a limit of diversion of 6,800 cubic feet per second. The Board recommends "that the provision for exacting payment is inexpedient." The reason given for the suggested limitation to 6,800 cubic second feet is explained by the following extract from its discussion: (Page 55).

> "Chicago is, therefore, debarred from any claim for indulgence as to work done and expenditures incurred in recent years. If, in defiance of the opposition of the Government, and in open disregard of the law, the officials of The Chicago Sanitary District have continued to expend the money of their constituents in the prosecution of unwise and illegal plans, these officials and their constituency are to blame, and they should expect no great indulgence from the general public whose government they have ignored and whose interests they have disregarded."

It should be pointed out, however, that the Board had in mind a "permanent diversion" while an initial permit for a diversion for a reasonably limited period is contemplated by the Sanitary District. That does not eternally commit the Federal Government to this diversion. When the time comes to exact every possible kilowatt of power out of the Great Lakes rivers and the Des Plaines, Illinois and Mississippi rivers as well, a new limit of diversion may be fixed. That time is of the future, not now. Many things are uncertain now. It is not improbable that when the time comes to exact every kilowatt of power from the outflow waters of the Great Lakes, the time will also be at hand to exact every pound of fertilizer out of our municipal sewage and exact every ton of carrying capacity in the inland waterway to the Gulf of Mexico. The writer of this review concurs with the Board in conservative limit of volume of **permanent diversion,** but dissents from the punitive motive which unfortunately is implied. Only one consideration enters after regulating works are in operation: Is a

volume of 10,000 cubic feet of water serving more usefully in its various functions—sanitation, navigation, power—in the route to the Gulf of Mexico, than in the route to the Gulf of St. Lawrence? In answering this question, navigation by the St. Lawrence route to the sea and scenic grandeur at Niagara are not involved because properly designed and operated regulating works will care for both. The only remaining loss is in **power** as the water descends the Niagara and St. Lawrence Rivers—and these regions are so rich in power that its full economic use is at least a half century away. A license for diversion for a period of years at Chicago instead of a fixed diversion **in perpetuity** presents a new aspect not considered in the Board's recommendation of 6,800 cubic-second-feet.

(30) Completion of Project—As reported by the International Waterways Commission, The Sanitary District by 1907 had expended 40 million dollars. At the present time the expenditure is over 100 million dollars. It may be asked, why—after the legitimacy of the diversion and its ultimate permissible volume were in question—any further work and any further expenditures should not have ceased. It should be remembered that the first permit was for 5,000 cubic second feet and that this was reduced to 4,167 cubic second feet by reason of restricted canal areas and high current velocities in the Chicago River. It was necessary to complete the project to make effective the investment already made. The right of the State to divert this water under its police power to protect life and health was confidently believed. The imperative need of dilution proportionate to the population compelled the enlargement of the congested portions of the Chicago River. The report of the International Waterways Commission in 1907 added to the confident expectation of the people. The Treaty of 1910 gave international sanction—but not a Federal permit. All these things have kept alive the robust midwest confidence in an ultimate equitable adjustment, with the full volume of flow permissible under the Treaty. Meantime expenditures are going on apace for auxiliary artificial purification stations to supplement the natural purification by the water of diversion.

(31) Super-Regulation—The Board report, as commented on in paragraph 29, is constructive in its vision of the possibilities of regulating works at the head of the Niagara River and in the St. Lawrence River. The Warren Report adhered to the simpler method of compensating works, which a decade ago were considered. The writer of this review in his Report on the Regulation of the Niagara and St. Lawrence Rivers (1919) demonstrated the safety and possibilities of the elastic control of

the outflowing waters under a budget system, and the mill-pond values of Lake Erie and Lake Ontario. The scheme proposed involved the interrelation of the control of the two rivers and lakes. Water release in the Niagara contemplated hourly, daily and monthly variations. The Board has gone further than the writer in recommending twelve-month operation and points out greater power use when the ice complication is eliminated by flushing. In this twelve-month control the writer fully concurs. His own design was suggested to meet the Buffalo objections, which have more weight psychologically than physically. Twelve-month control, with enlarged channel capacity in the Niagara River, will permit raising the mean level of Lake Erie not less than 18 inches in such normal decades as that of 1907-1916, and not less than 24 inches in such low-water decades as that of 1893-1902. These high levels for Lake Erie surface will more than compensate the diversion of 10,000 cubic second feet at Chicago, without compensating works in the St. Clair River, and no dredging will be necessary in Lake St. Clair to restore it for all diversions—that of Chicago, those in the Welland Canal and present and future diversions in the Niagara River. It should be added that the menace of flood stages in Lake Erie will disappear, when the flood relief outlets at Chicago and in the Welland Canal dispose of 15,500 cubic second feet and the flow capacity of the Niagara River is augmented by deepening the reach at Buffalo. The flood relief thus provided will make safe the maintenance through the winter months of a stage in Lake Erie of 574.0 feet. Super-regulation appears to be the ultimate solution of the problem of the economic use of the waters of the Great Lakes. One of the very remarkable correlaries in this matter of regulation is that the safe elevation at which Lake Erie may be retained—and flood damage hazard avoided—is higher by reason of the flood-water relief at Chicago and in the Welland Canal. Without any deepening in the Buffalo reach of the Niagara River to afford flood relief, the diversions in the two canals above mentioned will permit a higher level by three inches to be safely maintained in Lake Erie than would be permissible without these diversions. It follows from this that with effective regulation, navigation is a **beneficiary** of these diversions.

(32) Backwater—The backwater values for the Detroit and St. Clair Rivers derived from the Warren Report are widely divergent from the values computed by the Board of Engineers on Deep Waterways (1900) and widely divergent from the values used by the writer in his 1919 Report on Regulation. These are for mean stage:

AUTHORITY—	BACKWATER BASED ON LAKE ERIE IN LAKE ST. CLAIR	IN LAKE HURON
Deep Waterways Board	66.7%	33.3%
Shenehon Report	75.0%	34.4%
Warren Report	27.6%	13.8%

These percentages mean that when Lake Erie is raised 1.00 foot, the Warren Report finds a rise of 0.276 foot in Lake St. Clair and Lake Huron will be raised 0.138 foot. The physical unfitness of the Warren figures appears when the backwater efficiency of the St. Clair River with its fall of 5.5 feet is seen to be 80 per cent greater than the backwater efficiency of the Detroit River with its 3.1 feet of fall. The Board of Engineers on Deep Waterways by theoretical considerations found the backwater efficiency of the Detroit River 33 per cent more than that of the St. Clair River. The writer computed the St. Clair River backwater efficiency from the Lake Survey Equation of Discharge of the river in terms of the elevations of Lake Huron and Lake St. Clair, as shown graphically opposite page 14 of his Report on the Regulation of Niagara River. He determined by analysis based on the Chezy formula the backwater efficiency of the Detroit River. The backwater efficiency of the St. Clair River for 1.00 foot rise in Lake St. Clair shows close agreement of the three authorities:

AUTHORITY—	BACKWATER BASED ON LAKE ST. CLAIR IN LAKE HURON
Deep Waterways Board	50.0%
Shenehon Report	45.9%
Warren Report	50.0%

The backwater values for the Detroit River are believed to have been determined for the Warren Report by equations of flow of the river in terms of Lake St. Clair and Lake Erie elevations. The analytical problem presented, however, of untangling the effect of one lake from the other was so intricate that values which will satisfy an equation have a wide range. The backwater problem is more readily and accurately determined by direct approach. An example of what this backwater efficiency in the Detroit River really implies will make clear the incongruity of the values derived from the Warren Report (pages 89-90) of 0.276 foot rise in Lake St. Clair for 1.00 foot rise in Lake Erie. The fall of 3.1 feet in the Detroit River represents the potential expenditure to overcome the various energy losses from friction, eddies and varying velocities. The following tabulation shows the energy content in the fall between Lake St. Clair and Lake Erie under the backwater value of 27.6 per cent derived from the Warren Report:

ARTIFICIAL RISE IN LAKE ERIE FEET	FALL LAKE ST. CLAIR TO LAKE ERIE FEET	PERCENTAGE ENERGY USED
0.0	3.10	100
1.0	2.38	77
2.0	1.65	53
3.0	0.93	30
4.0	0.20	6+

With a mean depth of 20 feet for a fall of 3.1 feet, the new mean depth with Lake Erie raised 3.0 feet is less than 22 feet. Is it possible that with a change of 10 per cent in the hydraulic radius and 10 per cent in the cross-sectional area, the transportation of exactly the same amount of water may be accomplished with 30 per cent of its normal energy requirement? If on the other hand the backwater value is taken as 75 per cent the following relations obtain:

ARTIFICIAL RISE IN LAKE ERIE FEET	FALL LAKE ST. CLAIR TO LAKE ERIE FEET	PERCENTAGE ENERGY USED
0.0	3.10	100
1.0	2.85	92
2.0	2.60	84
3.0	2.35	76
4.0	2.10	68

It is very clear that the reason why less energy is required to transport a certain fixed volume of water through the Detroit River—when backwater creates greater depths—is that velocities become lower and hence the energy expenditures—which vary as the square of the velocity—are somewhat less. It will illuminate this situation to compute the energy required to transport a fixed mean volume of flow through the Detroit River, with assumed different mean depths. These energy requirements are based on the Bazin formula, with varying values of the coefficient depending upon different values for the hydraulic radius. Just one assumption is made: that the hydraulic radius equals the mean depth. This is very close to the truth in this wide river with flat cross-stream profile.

NO.	MEAN DEPTH OF RIVER	FALL IN FEET LAKE ST. CLAIR-ERIE	PERCENTAGE ENERGY USED
1	15	3.1	100.0
2	16	2.5	80.6
3	17	2.0	66.0

As the increase in the mean depth of the Detroit River for a two-foot artificial rise in Lake Erie is less than two feet, it is certain—with this

artificial Lake Erie rise of two feet present—that the energy requirement must be more than 2.0 feet; and consequently the backwater value must **much exceed** 50 per cent. It will be observed that the base or normal mean depth of the Detroit River is taken as 15 feet to make certain that no error may enter from the earlier assumption of 20 feet as the mean depth. The writer believes it obvious that the backwater values for the Detroit River in the Warren Report are widely in error. The restoration of navigable depths above the mouth of the Detroit River by raising Lake Erie is so vastly important in any scheme of regulation that this manifest error should be eliminated. Even with a value for the backwater efficiency of the Detroit River of 67 per cent and super-regulation operative, no dredging in Lake St. Clair and no compensating weirs in the St. Clair River will be necessary. The Report of the Board of Engineers for Rivers and Harbors estimated for dredging in Lake St. Clair and weirs in the St. Clair River an expenditure of $2,160,000. Unless much more than restoration is contemplated for Lake St. Clair, Lakes Michigan-Huron and St. Marys River, super-regulation makes this expenditure unnecessary. The writer of this review feels warranted in discussing the solution of the problem of regulation, because the Sanitary District appears by the Warren Report, in which the Board concurs, to share in the payment for the works required.

(33) Restoration Cost — While the Sanitary District, in a bill introduced in Congress on November 9, 1921 (H. R. 9046), has offered to pay into the Treasury of the United States such sum or sums of money as may be estimated by the Chief of Engineers to be the reasonable cost of constructing compensating works or regulating works, or both, it would manifestly be inequitable to permit The Sanitary District of Chicago to do this without granting to other agencies responsible for the lowering of lake levels the privilege of sharing in the cost of such works. The Board of Engineers on Deep Waterways (1900) reported on works to cost $796,923, with an additional dredging cost of $384,000—about $1,181,000 in all—to regulate Lake Erie at elevation 574.6 feet above sea level. These works might cost $1,800,000 in 1923. The effect of this regulation will more than offset any lowering of Lakes Michigan and Huron and the St. Marys River due to a diversion of 10,000 cubic second feet of water at Chicago. No additional submerged weirs will be necessary in the St. Clair River to accomplish this. The St. Clair River over a greater part of its length will be more than restored. At its mouth, in Lake St. Clair and at the head of the Detroit River the increased surface level height will be half a foot more than that existing prior to the opening of the Chicago Drainage Canal in 1900. At the mouth of the Detroit River and in Lake Erie

the surface level will be raised a foot or more above the mean stage existing prior to 1900. The limit of Lake Erie surface height depends, when super-regulation is effective, on the brim level of the lake itself, when it is so full that any greater rise would cause flooding of the low-lying shore lands or damage to harbor works. The brimful level of Lake Erie may be taken as 574.5 feet above sea level. It reached approximately this level as a monthly mean in 1862 and in 1876. In 1838 it reached the high water level of 575.1 feet. The writer in his Report on the Regulation of the Niagara River (1919) found the water supply tributary to the Niagara River—with no diversion—about 330,000 cubic feet per second during April, 1913. The outflow capacity of the Niagara River with Lake Erie at elevation 574.5 is 253,000 cubic second feet. Add to this the flood relief capacities of the Chicago Drainage Canal, 10,000 cubic second feet, the Welland Canal, 5,500, the Erie and Black Rock Canals, 2,400 cubic second feet, and the augmented river capacity by reason of expected power diversions in the Chippewa-Grass Island pool of the Niagara River, 7,100 cubic second feet, shows an aggregated flood disposal total of 278,000 cubic second feet. Add to this the reservoir capacity of Lake Erie between elevations 574.0 and 574.5 feet **accumulated in two months**—30,000 cubic second feet—and the maximum flood disposal and absorbing capacity is 308,000 cubic second feet. In the past 50 years the supply has only once—in 1913—exceeded this maximum capacity for two consecutive calendar months. While extreme prudence may make desirable some rock excavation in the Buffalo reach of the Niagara River, the increased flow capacity does not need to be increased by this process more than ten per cent. This will mean that at Lake Erie stage 574.5, which may some time come in May or June, the new outflow capacity—without power company increment—will be 278,300 cubic second feet and the total capacity for disposal without mill pond absorption will be about 303,000 cubic feet per second. This capacity appears sufficient when it is remembered that advance warning is given by the opulent precipitation in the watershed and brimming levels in Lakes Superior, Michigan and Huron. With flood conditions forecasted, Lake Erie, and Lake Ontario as well, can be pulled down to develop reservoir capacity to aid in absorbing any flood flow to come. A fund of one million dollars compounded annually for 50 years at 4 per cent interest will become $7,106,680. It may be sounder economically to save the expenditure of a million dollars in rock excavation—when the omission of the improvement may risk a trivial damage to riparians once in 50 years. The removable gates designed by the writer for the Niagara River regulation were estimated to cost about $1,224,000. The super-regulating dam recommended by the Board of Engineers for Rivers

and Harbors in the Review of the Warren Report is estimated to cost $8,000,000. It is surmised that some considerable portion of this expenditure must be for rock excavation. While the Sanitary District is ready to assume a reasonable burden of expense in undoing any damage to the Great Lakes, the Board of Engineers itself recognizes that other agencies should cooperate. The various lowerings of Lake Erie in the future may be set down as follows:

Chicago diversion	10,000 c.s.f.	0.46 ft.
Welland Canal	5,500 c.s.f.	0.26 ft.
New York Canals	2,400 c.s.f.	0.06 ft.
Niagara Power Companies		0.32 ft.
Total lowering		1.10 ft.

The Sanitary District's share of this is 41 per cent. It should be frankly acknowledged, however, that Lake Erie must be raised the full practicable amount to offset completely the lowering in Lakes Michigan and Huron and in the St. Mary's River. Since super-regulation, however, adds to the permissible power use on the Niagara and St. Lawrence Rivers, and avoids daylight meagerness of flow at Niagara Falls, the beneficiaries of these things must not be forgotten. The recommendation of the Board of Engineers is for division of expense between the two governments. What this means as to The Sanitary District's share is not clear; perhaps with a diversion of 6,800 cubic second feet, nothing. The writer in his Report on the Regulation of the St. Lawrence River estimated the works to cost a million dollars. Here again super-regulation is imperative and the works now contemplated will prove part of a power dam. A contribution of a million dollars toward this is suggested by The Sanitary District.

(34) Differential Diversion—All this discussion really hinges on a quantity of diversion which represents the difference between the designed capacity of the Drainage Canal—10,000 cubic second feet—and the diversion recommended by the Board of Engineers for Rivers and Harbors—6,800 cubic second feet. As the recommendations of the Board of Engineers will have great weight with the Committees and Members of Congress, the differential quantity, 3,200 cubic second feet, needs to be examined. With regulation effective this is an absolutely negligible quantity from the navigation standpoint. It is less than the diversion for power purposes by Canada in the Welland Canal, and has less effect on Lake Erie when uncompensated. Its single significance is in **power.** The only justification for withholding this differential diversion so far as power is concerned **begins** when every

practicable kilowatt of power is developed and usefully employed. More than six times the power in this differential diversion is now wasted by the inefficiencies of the present Niagara Falls plants. (See paragraph 13 of this review.) More than seventeen times this power is unused in the Niagara River. More than sixty times this power is running to waste in the St. Lawrence River.

(35) Rate of Diversion—The very nature of the diversion in the Chicago Drainage Canal points to the fact that the superior usefulness of the water will come from some elasticity in the variation of the rate of diversion. A high volume of flow is sanitarily desirable in the hot mid-summer months, when the temperature of the water may accelerate putrefaction and cause stench. This is particularly true when the natural flow of the Illinois River is low. A larger volume of flow during such periods will be helpful also to navigation. On the other hand, in midwinter, when the water is close to the freezing point, putrefactive processes are slow and navigation is suspended. A lesser volume of flow will serve under these conditions. It will be in the best interests of conservation to fix the conditions of diversion such that the limitation applies to a mean value for the calendar year. This will make for the maximum effectiveness of the water diverted and will not affect adversely the Great Lakes System. The water power content of the Niagara and St. Lawrence Rivers will be precisely the same, whether the diversion at Chicago is 10,000 cubic second feet per day, per month or per year. It will be wise to fix the limitation as applying to a calendar year, and place in the hands of the Secretary of War authority to regulate variations in the rate of flow so that no obstructive currents may be caused in the Chicago River. The reason why the variation in flow will not affect adversely any interests in the Great Lakes System arises from the fact that the great reservoir values of Lakes Michigan, Huron and Erie serve to absorb and delay the effects of diversions. A permanent diversion is not felt in any measurable degree in Lake Erie or in the Niagara River for a year or more after the diversion begins. Variations in diversion throughout the year will not be transmitted through these vast retarding basins.

(36) Conclusion—The equitable conclusion of the International Waterways Commission has already been mentioned. In the Canadian Compilation referred to in paragraph 18 of this review, paragraph 19 on page 520 reads as follows:

> (19) "In the expenditure of $40,000,000 for the drainage canal the people of Chicago, with its population of 2,000,000, incurred a burden equivalent to that due to an expenditure of $1,600,000,000 by the United States, with its population of 80,000,000 — that is, enough to build eight

or more Panama canals. It was a very serious effort and has commanded the admiration and sympathy of all observers. The diversion of 10,000 cubic feet per second from Lake Michigan affects other interests adversely, but these interests have withheld their opposition, seeming to believe that some such amount was necessary, and apparently willing to contribute their share to protect the lives and health of the people of a great city. The plans calling for that amount have been under public discussion for some years. Although withholding formal approval, the Federal authorities have taken no steps to prevent their execution. Congress has called for a plan and estimates for an improvement of the waterways connecting with it, the scope of which is fixed by that amount. There appears to be a tacit general agreement that Chicago needs or will need about 10,000 cubic second feet of water for sanitary purposes and that the city should have it without question."

In this equitable conclusion the Canadian Section concurred with the American Section.

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APPENDIX "C"

Report of E. L. Cooley, Hydraulic Engineer, to Edward J. Kelly, Chief Engineer of the Sanitary District of Chicago, regarding Flood Flow in the Chicago River.

Chicago, August 21, 1923.

Mr. Edward J. Kelly,
Chief Engineer.

Dear Sir:

(1) About the notable storm of August 11, 1923, when the Chicago River discharged a large volume of sewage water into Lake Michigan during a period of at least six hours and polluted the public water supply. The following notes and discussion are submitted for what they are worth. As you will see, an argument has been made for a larger flow through the canal. Most of the notes have been appended to the discussion.

(2) As reported by the Chicago office of the U. S. Weather Bureau, the local rainfall was 2.68 inches early Saturday morning and 1.00 inch more Saturday night, a total of 3.68 inches in 24 hours on the Chicago area, Aug. 11, 1923. The above figures are from newspaper reports. Mr. Mitchell of the U. S. Weather Bureau was quoted as saying: "The records contain a large number of instances wherein more than three inches fell within twenty-four hours." This applies to the Chicago area.

(3) The storm of Aug. 11, 1923, overloaded a great many if not all of the Chicago sewers. The run-off period was prolonged by water ponded in subways, basements, and on the surface in the outlying areas where streets were flooded to the tops of the curbs. In many areas water was stored below street level in yards and lots with small sewer inlets and some of the water had time to soak into the ground. As a rule the street inlets are too small and in some large areas the sewers should have about double the present capacity. In the near future with more impervious area and larger run-off, more relief sewers, better inlets, and additional sewered area, it is quite obvious that the normal rate of stormwater run-off will be much larger than it is at the present time; consequently the rate of flow in the river and down the canal will be much larger.

(4) We have had record floods of 4,000 c. f. s. or more out of the North Branch. Since then the "Armour Ditch" has improved the

middle fork from Rondout to the County Line and the drainage of about 30 square miles in the Skokie north of Willow Street, Winnetka, is due to be improved. Formerly the run-off from about 60 square miles has been stored for a time in the extensive marshes of these two forks. The North Shore Channel has improved the drainage of a large area and its tributary sewers now intercept the run-off from a number of square miles formerly draining into Lake Michigan. More area further north may be added as the North Shore villages develop. In the not distant future with these marshes better drained, and with more tributary sewers, it is reasonable to expect a record flood of at least 5000 c. f. s. out of the North Branch alone.

(5) When the Sanitary District law was framed in 1887 the estimated stormwater run-off of the Chicago area was 10,000 c. f. s. and the Sanitary Canal was originally designed to carry this estimated run-off from the Chicago area. Later the Calumet-Sag Channel has been built with a nominal capacity of 2,000 c. f. s. and the Calumet area has been added to the Chicago area. Under a moderate hydraulic grade the Calumet-Sag Channel will easily carry 2,500 c. f. s. when the Hegewisch-Dalton-Harvey area has been added to the Calumet area and this should be the flood capacity. On this basis the combined flood capacity of both channels will be 12,500 c. f. s. or exactly 3 times the 4,167 c. f. s. allowed by the federal permit. Incidentally, with a limited flow of 4,167 c. f. s. the two channels would gradually silt up as has been the case in the Grand Calumet Channel to Hammond dredged some years ago by the U. S. Engineers. Until more sewers are built and the reach of the Calumet river from the Forks to the Canal at Blue Island has been dredged to capacity the Calumet-Sag Channel is not expected to carry its full rated capacity. Under present conditions without a self-cleaning current it probably is slowly silting up. A few years after the Main Channel was opened in 1900, with an average flow of 4,000 or 5,000 c. f. s. a deposit several feet deep was found in the reach of canal from Summit to Willow Springs.

(6) With a flow of $10{,}000 + 2{,}500 = 12{,}500$ c. f. s., the flow will be $3 \times 4{,}167 = 12{,}500$ c. f. s. and the slope ratio will be 1 to 9; but at the present time the Calumet-Sag Channel does not maintain this relation. Neglecting the tributary Sag Channel and assuming A and C constant in the formula $Q = A\,C\,\sqrt{R\,S}$: Then with a flow of 10,000 c. f. s. in the Main Channel the slope from Lake Michigan to the Power Plant will be 5.76 times the slope with a limited flow of 4,167 c. f. s.; with proper values of A and C the slope ratio will be about 1 to 6. With the Sag Channel tributary included the slope ratio will be considerably more than 1 to 6; but data to work out this complicated hydraulic relation is not at hand and the available time is short. A slope ratio of 1 to 6

is assumed: Then under average conditions with a limited flow of 4,167 c. f. s. the total slope will be 1 foot, and 6 feet for a flow of 10,000 c. f. s. This assumed relation is reasonably close to the data at hand. Under present working conditions a case of uniform flow does not occur in a period of 8 hours. When the heavy lighting load goes off in the morning the canal gauge at the Power Plant is still falling about half a foot an hour. A test made some years ago indicated that it took more than 24 hours to establish uniform slope with a uniform flow somewhat less than the maximum. When the test began the flow was about half the test flow. It took a long time to run off the water stored in the Main Channel. Under present conditions the time would be less. The stored water question is discussed in more detail in paragraphs (9), (10), and (11).

(7) With a limited uniform flow of 4,167 c. f. s. the total declivity of 36 miles of river and canal from Lake Michigan to the Power Plant is assumed to be 12 inches, or an average of 1 inch in 3 miles. In this case the water surface at Lake Street will be less than 1 inch below lake level, assuming a local declivity of 2 inches to 3 miles. The area of all the water surface including the Main Channel, Sag Channel, and the various branches and forks of the Chicago River is more than 75,000,000 square feet. If Lake Michigan should fall 1 foot in an hour or two, as it does several times a year, it would take 5 or 6 hours to run off one foot of stored water and reestablish the flow from the lake, if no water flowed back into the lake; but with the water surface at Lake Street about 11 inches above lake level there would be a rapid flow back into the lake and the North Branch and perhaps all the South Branch would flow back into the lake for several hours. If the lake should fall 2 feet, as it does once or twice a year, the back flow would be larger and would last a longer time. It is not worth while to work out such a case in minute detail; a variation of 2 or 3 inches will not change the general conclusion. The fact remains that with a limited flow of 4,167 c. f. s. the Chicago water supply would be threatened a number of times each year, and probably that sedimentation in the river and canal would cause a public nuisance.

(8) Assume that with a limited flow of 4,167 c. f. s. we are permitted to increase the flow during or after a storm: This is not a safe working condition. It is hard to anticipate the time and magnitude of a storm. About half the storms occur at night. It is not proposed to transfer the operation of the canal to the Weather Bureau. The safest way is to have an established flow of at least 10,000 c. f. s. when the storm begins. Once or twice a year the safe flow should be more than 10,000 c. f. s. as was the case on Aug. 11. Except the Sag Channel and the upper forks of the North Branch practically all the tributary storm

waters come in through sewers and nearly all of these sewers may be discharging at a maximum rate an hour or two after the storm begins. This was the case for both the intense storms of Aug. 11, one before daylight and the other after dark. Without going into the minutiae of time intervals and gauge relations it may be stated that the storm-water sewage was flowing into the lake at 6 A. M., Aug. 11, and perhaps 3 hours earlier, and that the river continued to flow into the lake until about 12:30 P. M. and was practically at a stand during most of the afternoon, all as observed by a number of people who had business on the river. The conditions due to a long steady storm need not be discussed at this time.

(9) After the lighting load at the Power Plant went off at 4:30, Aug. 11, the average flow from 4:30 to 9 a. m. was 4,340 c. f. s. by Mr. Ramey's estimate. From 9:30 a. m. to 7:30 p. m., a period of 10 hours, the average flow was 12,350 c. f. s.; the average for the first 5 hours was 13,330 c. f. s. and for the maximum hour was 15,270 c. f. s. The river continued to flow into the lake for 3 hours after the big flow began at the Power Plant. The 10-hour average at the rate of 12,350 c. f. s. included a large volume of water stored in the canal before the flow was increased at 9 a. m. From 7 to 9 a. m. the canal gauge stood about —1.4 at the Power Plant; usually this gauge reads 3 or 4 feet below datum during this period. Much of this early surplus water may have come out of the Sag-Channel and its I. & M. Canal tributary, all draining an area of more than 100 square miles. Another part may have come from the large sewers of the S. W. Side. It takes 2 hours or more for a large increase in flow at the Power Plant to begin to show on the Western Ave. gauge and conversely flood waters from the S. W. Side would not begin to show on the Power Plant gauge in less time. With an average velocity of 3 feet per second it would take nearly 15 hours for a given volume of flood water to traverse the Canal from Western Ave. to the Power Plant. The additional time for 6 miles of river has not been estimated; at the same rate it would add about 3 hours.

(10) In paragraph (6) it was stated that "under present working conditions a case of uniform flow does not occur in a period of 8 hours. When the heavy lighting load goes off in the morning the canal gauge at the Power Plant is still falling about half a foot an hour." This was true during the night of August 8-9, 1923. From 8:30 p. m. to 4 a. m. the water surface in the canal at the Power Plant fell from —1.5 to —6.75, a range of 5.25 feet. The average flow as indicated by 16 half-hour readings was at the rate of 11,100 c. f. s. The average flow for 24 hours was at the rate of 7,930 c. f. s. If 75,000,000 square feet of water surface fell half as far as the fall on the canal gauge at the Power

Plant the displacement was at the rate of 5,200 c. f. s.; if the water surface fell 1-3 as far the rate was 3,500 c. f. s. In other words, at 4 a. m. August 9, stored water was running off at the rate of 3,500 or 5,200 c. f. s. Because the center of area is more than half way up the Channel and because of the extra slope in the 12-mile reach below the Sag Junction, the smaller value may be about right for the last hour of the 8-hour night run August 8-9. Without a series of gauge readings at critical places the displacement of stored water cannot be estimated precisely.

(11) During the night of August 9-10, 1923, from 8:30 p. m. to 4:30 a. m. the water surface in the canal at the Power Plant fell from —3.1 to —7.3, a range of 4.2 feet. The average flow as indicated by 16 half-hour readings was at the rate of 10,900 c. f. s. The average flow for 24 hours was at the rate of 7,220 c. f. s. The canal gauge from 1:30 to 4:30 a. m. was falling quite uniformly at the rate of 1 foot in 3 hours or 1-3 foot per hour. If 75,000,000 square feet of water surface fell 1-6 foot, the displacement was at the rate of 3,500 c. f. s.; and if it fell 1-9 foot the rate was 2,300 c. f. s. As before, the smaller value, 2,300 c. f. s., may be about right for the last hour of the 8-hour night run, August 9-10. The corresponding rate the night before was 50 per cent larger, but there was more stored water the night before. Incidentally nearly 2 inches of rain fell on August 6-7-8. Variations in lake level and in river slope may have been factors. With so many variables it is useless to split hairs over two solitary observations. A long series would be more conclusive. But it is very evident that stored water is a considerable factor under present conditions. And it takes a long time to run off stored water when a storm comes with a high stage in the canal. In the meantime sewage water may be flowing into Lake Michigan as was the case for at least 6 hours and probably 9 hours following the storm of August 11, 1923.

(11a) It should be added that during the first 3 or 4 hours of the usual night run more than half the water used is stored water. The flow from the lake begins to increase not less than 3 hours after the large increase in flow begins at the Power Plant.

(11b) The use of the name Power Plant in this discussion indicates the present end of the canal and should not give undue prominence to the incidental by-product of a great work which ultimately will cost Chicago more than $100,000,000. Contrary to the assumptions of certain alien critics in Canada and Wisconsin the Power Plant is not an institution for profit; it is a liability and not an asset. At present most of the power is consumed in lighting the streets of Chicago at a loss to the Sanitary District. Ultimately much of the power will be

used to pump water and sewage. The tax-payers of Chicago will derive whatever benefits may flow from the Power Plant.

(11c) It was contrary to public policy to permit private institutions for profit to appropriate this water power which they had done nothing to produce. When such institutions acquire a vested interest they may interfere with the original design and subvert a public work to their own private use and profit. Such was the Illinois and Michigan Canal case some years ago. The old Lockport mills held a lease for power at a nominal rate ($4.00 per horse power per year) from the then Illinois and Michigan Canal Commission and at one time the Sanitary District and later the Illinois and Michigan Canal Commission operated the Bridgeport pumps at a loss to maintain the mill interest. Incidentally the Canal Commission paid the mill people more for current to operate the pumps than they got back on the lease, to say nothing of the cost of maintaining and operating the Bridgeport pumping station. It is not clear who paid the cost of the transmission line from Joliet to Bridgeport. At that time a Lockport man, the late Mr. Norton, controlled both the Lockport mills and the water power plant at Dam No. 1 in Joliet.

(11d) During this period some speculators pre-empted a mill site on the river just below Joliet and made a lot of trouble. This case was in the courts for a number of years. Further down stream we had the Dresden Dam case. The Marseilles water power interests have stood in the way of the State canal project. Some promoters claimed a power site near Ottawa. All of these predatory interests claimed a right to a flow which they did not produce and curiously all of them had standing in the lower courts. About 25 or 30 years ago Gen. Doe was sent by the War Department to investigate certain complications in the Wisconsin-Fox river canal case. The water power interests had impaired navigation in the canal and there were other complications. Other cases could be cited. To avoid private water power entanglements has been the unwritten policy of many United States Engineers on waterway improvements and it has been the policy of The Sanitary District of Chicago.

(11e) In conclusion it should be stated that a limited flow of 4,167 c. f. s. through the Sanitary Canal is inimical to the welfare of Chicago; that Lake Michigan and the water supply of Chicago would be polluted by sewage many times every year as outlined in this report; that oscillations in lake level would cause the river to flow back into the lake at intervals during dry weather periods; that during storm periods the discharge of the North Branch alone at times may equal or exceed the limited flow of 4,167 c. f. s.; that for a time, August 11, 1923, the whole flood of the North Branch did flow into Lake Michigan and that

such storms are not of rare occurrence as stated by Mr. Mitchell of the United States Weather Bureau; that sewage flowed at least 2 miles out into Lake Michigan; that in time deposits and sedimentation would produce an intolerable nuisance, and would impair the usefulness of the canal for commerce, and would reduce the capacity for carrying stormwater; that the combined flood capacity of the Main Channel and the Calumet-Sag Channel is and should be at least three times the limited flow of 4,167 c. f. s.

(11f) On the other hand with a normal flow of 10,000 c. f. s. through the Main Channel as was estimated in 1887 when the Sanitary District law was framed: The Main Channel was originally designed for a normal capacity of 10,000 c. f. s. although the Boldenweck-Eckhart board of trustees lost sight of this fact when they applied for the Federal permit. This capacity was adopted to avoid the necessity of building the so-called Bowmanville Cut-off designed to divert the flood waters of the Des Plaines River and the North Branch into Lake Michigan. A by-pass from the lake to the river south of 16th Street was contemplated but was not built. The Main Channel was to begin at the west end of this by-pass and be about 300 feet wide between dock lines so that ships could lie by. The alternatives of heavy work in the river around the loop area and high velocities in the river were to be avoided. The water section of this by-pass was to be about 100x25 feet with concrete sides and invert and the street crossings were to be level and full width with parapet sidewalls. The flow through the by-pass was to be controlled by headworks and the velocity through the river adjusted to suit the needs of navigation. The available slope or rate through the by-pass would have been 4 or 5 times the river slope, with equivalent velocities, but by closing the by-pass at intervals the river could be kept free of deposits. So much for early history.

(11g) After the storm of August 11 an average flow of 12,350 c. f. s. was maintained for 10 hours at the Power Plant and at the same time the main river flowed into the lake for about 3 hours and was practically at a stand for 7 hours more. The flow from the Calumet-Sag Channel has not been estimated but it is assumed that at least 10,000 c. f. s. was carried for several hours by the Main Channel above the Sag Junction. For want of specific data the complicated relations of tributary waters and stored waters have not been estimated in the South Side area but it seems clear that a channel capacity of less than 10,000 c. f. s. would be inadequate. It should be borne in mind that the rainfall of 2.68 inches early August 11, 1923 and 1.00 inch more about 20 hours later, a total of 3.68 inches, was not a great storm. Mr. Mitchell stated that the Chicago Weather Bureau records "contain

a large number of instances wherein more than 3 inches fell within 24 hours." During the month of August, 1885, the total rainfall was 11.28 inches; August 2-3 within a period of 24 hours the rainfall was 6.19 inches. This historic storm caused the agitation that produced The Sanitary District of Chicago.

(11h) In conclusion it should be stated that the proposed flow of 10,000 c. f. s. is not for the benefit of Chicago alone. Compared with conditions before the canal was built the proposed flow will improve navigation in the Illinois river and will raise the low water stage of the Mississippi River about one and one half feet at St. Louis and benefit navigation in the Mississippi Valley. It will be a self-sustaining benefit and will improve the stability of the lower river in a number of critical places by reducing the range from high to low water. And finally the larger flow is an important factor in the proposed Lakes to Gulf waterway.

Respectfully submitted,

E. L. Corthell.

Hydraulic Engineer.

NOTES

(12) Mr. John Meyer, engineer of the tug Arctic, tied up all day at the Goodrich dock east of Michigan Avenue, came on at 6 a. m., August 11, and observed the river flowing towards the lake from 6 a. m. until noon; the river stood still from 12 to 2 p. m. and then slowly flowed west. The water was very dirty with sewage and oil on the surface and he was sure that the oil came out of the North Branch.

(13) When Mr. W. R. Matthews of the City Sewer Department crossed the Washington Street bridge about 8:30 a. m., August 11, he observed the river at a stand. At that time all of the sewage flood from the North Branch must have been discharging through the main river into Lake Michigan.

(14) Mr. Fred E. Delaney, pilot of the fire-boat Graeme Stewart tied up at the foot of LaSalle Street, came on watch at 7 a. m., August 11, and observed the river running east at that time. At 11:30 a. m. the Str. Iroquois had trouble landing at the dock, just east of the fire boat. Her stern would not swing around against the east-bound current and they got out a line and warped the stern in. The east-bound current continued until 12:30 p. m.

(15) Mr. James Hefferman, chief engineer of the fireboat, who also came on watch at 7 a. m., August 11, said the water was flowing east at 7 a. m.—oil and sewage and refuse on the water. The flow continued until about 3 p. m. when the water came to a standstill. Evidently Mr. Hefferman did not see the change after 12:30 p. m. observed by Mr. Delaney.

(16) Mr. F. Beaver, bridge operator, south end of Dearborn Street bridge, came on watch at 8 a. m., August 11, and saw the water flowing towards the lake all the time up to 12:30 p. m. He did not notice any east current from 12:30 to 3 p. m. Bill Saville was on watch from 12 to 8 a. m., August 11, and is now on vacation. At the State Street bridge the man in the south tower was a substitute for a man on vacation. Mr. Miracle in north tower did not have a very distinct recollection of what the river was doing. He was down below pumping out the sump for some time.

(17) Mr. Joseph H. Stoke in the south east tower of the Michigan Avenue bridge was on watch from 8 a. m. to 4 p. m., August 11, and noticed the river current flowing to the lake when he came on watch until 1:30 p. m. At 1 p. m. he noticed a slight current to the west. The water was covered with sewage and oil. Sunday he did not notice any current towards the lake. The Customs office clerk in the south west tower was busy on his books and did not notice the river. The man on watch in the Harbor Master's office in the northeast tower confirmed the usual observations from 8 a. m. to 12 noon; after that he did not notice the river so much. Mr. R. Emerick in the northwest tower came on watch at 8 a. m., August 11, and thinks the current was towards the lake all day August 11 and 12. At 8:15 a. m., August 12, a man on the Str. City of Holland swept about a barrel of waste paper into the river and the paper floated slowly east. The Holland was at the Graham and Morton dock east of Wabash Avenue. It should be noticed in passing that an oscillation in lake level due to the high wind the night before may have caused this back current. The time, 8:15 a. m., August 12, does not check with time given in paragraph (23). Emerick may have confused the City of Holland with some other boat.

(18) Capt. Young at the Tug Office about half a mile east of Michigan Avenue confirmed the general report but did not observe the water very closely. At the United States Lighthouse Cottage just east of the Tug Office the man said the water was black and dirty on the morning of August 12 and appeared to be on a stand. The river is quite wide here and any current must have been comparatively slow.

(19) Capt. Daugherty of the Str. Iroquois who went out about 2 p. m., August 11, observed much dirty water in the outer basin. When he came in about 10 a. m., August 12, he saw dirty water in Lake Michigan half way out to the Carter Harrison crib and thought it came out of the river. The Str. Iroquois makes daily trips to South Haven, Mich.

(20) At the Goodrich Transit Co. dock Capt. Stufflebeam, Str. Alabama, said he went out about 7:45 p. m., August 11, and observed sewage and dirty water extending more than half way to the Carter Harrison crib; they ran through it for 5 minutes and it takes 9 minutes to pass the crib. When he came in about 5 hours earlier he noticed the black water about the same place.

(21) Capt. Moody, Str. Christopher Columbus, said that he went out about 10 a. m., August 11, and noticed a lot of dirty water out at the head of the pier. His boat makes daily trips to Milwaukee.

(22) Capt. Bjork, Str. City of Saugatuck, landed at dock about 3 a. m., August 11. The river was running towards the lake at that time. He left at 1:30 p. m., August 11—current towards the lake or at a stand? This report

indicates that the river was flowing towards the lake 2 or 3 hours after the storm began, depending on whether the Captain was using standard or City time. He is the only night witness interviewed.

(23) Capt. McCaley, Str. City of Holland, came to dock at 6:50 p. m., August 11; current to lake. Some sewage near Life Saving Station. Went out 11:30 p. m., August 11, current running to lake. The writer did not have time to complete this interview.

(24) Capt. D. A. McDonald, Str. City of St. Joseph, came to dock about 4 a. m., August 11; water at standstill. Went out 2 p. m., Aug 11. Saw sewage along the Morton Salt Works. The Captain did not remember much detail and was in a hurry.

(25) Mr. Woerman of the United States Engineer's Office observed, at 11:45 a. m., August 11, a mass of sewage inside the break-water. He also saw traces of sewage outside the break-water. Mr. Ramey says Mr. Woerman has more information.

(26) Mr. C. S. Rowe, Engineer Bridge Construction, City of Chicago, ran a surface float from the east side of the Clark Street bridge in center of south draw to the east side of the Dearborn Street bridge. The distance was $320+80=400$ feet and the time was 5 minutes, from 10:15 to 10:20 a. m., August 11, $V=400\div5x60=1.33$ feet per second to east.

(27) Other observations were made as follows:

W. M. Trinkaus, 10:45 a. m., surface $V=0.5$ to east.
Mr. Woerman, 11:45 a. m., surface $V=0.33$ to east.
W. M. Trinkaus, 1:15 p. m., current to west.

The first velocity observation at 10:20 a. m. (26) indicates a flow at the rate of 4,000 or 5,000 c. f. s. into Lake Michigan at least 4 hours after John Meyer (12) observed a current towards the lake and 7 hours after Capt. Bjork (22) observed a flow in the same direction. At 8:30 a. m., Mr. Matthews' observation (13) indicates that all the sewage flow of the North Branch was to the lake.

Respectfully submitted,

E. L. C.

Hydraulic Engineer.

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